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Descriptions of New Serpulid Polychaetes from the Kimberleys of Australia and Discussion of Australian and Indo-West Pacific Species of *Spirobranchus* and Superficially Similar Taxa

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Abstract. In 1988 Pat Hutchings of the Australian Museum, Sydney, undertook an extensive polychaete collection trip off the Kimberley coast of Western Australia, where such a survey had not been conducted since Augener's (1914) description of some polychaetes from the region. Serpulids were well represented in the collection, and their present study revealed the existence of two new genera, and new species belonging to the genera *Protula, Vermiliopsis, Hydroides*, *Serpula* and *Spirobranchus*. The synonymy of the difficult genera *Spirobranchus, Pomatoceros* and *Pomatoleios* is also dealt with. Certain difficult taxa currently referred to as "species complexes" or "species groups" are discussed. For this purpose it was considered necessary to undertake a comparison of apparently similar species, especially of *Spirobranchus*, from other locations in Australia and the Indo-West Pacific region. It revealed the existence of many more new species, which are also described and discussed below.

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Introduction

This major study of Polychaeta of the family Serpulidae Rafinesque, 1815, collected by Pat Hutchings from the Kimberleys of Australia in 1988, consists of twenty-four species belonging to nine genera, of which two genera and fourteen species are new. One of the latter belongs to the filogranin genus *Kimberleya* (new), one to *Pseudoprotula* (new), one to *Vermiliopsis*, seven to *Hydroides*, two to *Serpula*, and two to *Spirobranchus*. The study also addresses problems relating to similar but distinct species of certain genera from other locations in the Indo–West Pacific which had previously been identified as belonging to one and the same species, as well as those that had in recent years been designated as "species complexes" or "species groups" for want of adequate characters to satisfactorily separate them. Among them are species *Vermiliopsis, Hydroides, Serpula* and *Spirobranchus*. For instance, although *Hydroides tambalagamensis* Pillai, 1961, was first described from Sri Lanka, and later reported from Australia, Japan and China, superficially similar material in the Kimberleys collection turned out to be a new species, and the same as that referred to from Australia, Japan, and China. Another is the "*Vermiliopsis infundibulum/glandigera* group". Rather than assigning *V. glandigera* occurring in the Kimberleys collection to the latter, evidence is provided for separation of the two species composing it. The difficult genus *Spirobranchus* was especially interesting in this respect. Besides dealing with synonymy of *Pomatoceros* Philippi, 1844, and *Pomatoleios* Pixell, 1913, with *Spirobranchus* Blainville, 1817, it was found that there are at least two groups of similar species, those similar to *Spirobranchus tetraceros* (Schmarda, 1861), and those similar to *S. latiscapus* (Marenzeller, 1885). Their separation involved comparisons with collections available in the AM and NHM, which revealed the existence of at least seven species having a *S. tetraceros*-like operculum, of which three are new, and five having a *S. latiscapus*-like operculum bearing stacked discs, of which four are new.

The earliest contributions to our knowledge on serpulids from Australia and New Zealand and/or their distribution, were those by Schmarda (1861), Haswell (1884), Ehlers (1904, 1907), Augener (1914), Johansson (1918) and Benham (1916, 1927). They were followed by Dew (1959), Straughan (1966, 1967a,b,c), and Hutchings (1982).

Several authors have dealt with serpulids from other locations in the Indo-West Pacific: among them, Marenzeller (1885), Willey (1905), Pixell (1913), Monro (1939), Pillai (1960, 1965, 1970, 1971), Fauvel (1953), Imajima & Hartman (1964), Reish (1968), Gibbs (1971), Imajima (1976, 1977, 1978, 1979, 1982), Uchida (1978), ten Hove & Weerdenburg (1978), Chen & Wu (1978, 1980), and Wu & Chen (1978, 1981), Muhammad (1971), ten Hove & Jansen-Jacobs (1984), Imajima & ten Hove (1984, 1986), and Bailey-Brock (1985, 1987). More recent works include those by ten Hove & Smith (1990), ten Hove (1994), Pillai & ten Hove (1994), ten Hove & Nishi (1996), Ishaq & Mustaquim (1996), Nishi & Asakura (1996), Fiege & Sun (1999), Fiege & ten Hove (1999) and Sun & Yang (2000, 2001a,b). Among the species of *Hydroides* dealt with by Bastida-Zavala & ten Hove (2002, 2003) are two that occur in the Western Atlantic as well as the Indo-West Pacific Region.

Material and methods

The islands off the Kimberley Plateau, North Western Australia, from where the serpulids described in this paper were collected are shown in Figure1.

All available specimens, from juveniles to adults were studied in order to obtain as much data as possible on ontogenetic changes in characters, such as, in the operculum, number and arrangement of radioles, abdominal segments and arrangement of abdominal uncinal tori.

Many specimens possess complete tubes, some only tube fragments, while the tubes of others are missing. Since tube characteristics are best observed prior to extracting the worms from within, the following procedures were carried out under a low-power stereomicroscope with the specimens placed under alcohol in a laboratory dish. They were first cleaned using a paintbrush with stiff bristles. Calcareous overgrowths were removed with a fine-tipped surgical scalpel avoiding damage to tube ornamentation, and then measured and illustrated. To extract the worms, each tube was fractured as follows. It was firmly held with a pair of forceps; then the blunt edge of an ordinary laboratory scalpel was placed across it with its pointed end resting on the dish, and appropriate pressure was applied at intervals, from its anterior to posterior end, taking care not to damage the worm within. For juvenile specimens, a firm bent mounted needle was used in a similar manner, applying pressure along the tube with the convex side of its bend.

The following routine measurements were carried out, depending on completeness of available specimens. Tubes: total length, maximum diameter; height at aperture and maximum width, including lateral flanges. Worms: total length from tip of longest radiole or operculum, whichever is longer, to posterior end of abdomen; width of thorax at level of collar fascicles; length of thorax from collar to last thoracic segment; length of operculum plus peduncle; length and diameter of opercular plate; longest radiole, including, if found uncontracted, its pinnule-free tip; and length of abdomen. Counts: number of radioles on each side, and, if spirally arranged, the number of spirals to record maximum number encountered; number of pairs of thoracic chaetigers, or number on each side, if different; number of abdominal segments, and number bearing capillaries at its posterior end.

Slides were prepared in Gurr's Aquamount of the following: collar chaetae teased out form an entire collar fascicle, some thoracic and anterior abdominal tori, and the terminal abdominal segments of one side. Carbon-dioxide bubbles released by the mounting medium reacting with calcareous matter in the tissues were lifted off with the bend of a curved mounted needle before placing the cover glass, and then baked in a slide oven.

Drawings were made under low and high power magnifications with the aid of drawing attachments. For collar chaetae, they consisted of the blade, the boss and part of the chaetal shaft. For detailed comparisons between species, they included those recently formed within the collar fascicles and had not been subjected to abrasion, as well those earlier formed ones projecting outside the fascicle that had been subjected to abrasion with use. The number and arrangement of teeth in the thoracic and abdominal uncini and shape of their most anterior tooth were noted.

Figure 1. The islands off the Kimberley Plateau North Western Australia from where the serpulid polychaetes described in this paper were collected.

Abbreviations and terminology used

Tube. Median longitudinal ridge (*MLR*); lateral longitudinal ridge (*LLR*) = longitudinal ridge on either side of *MLR*; outer lateral longitudinal ridge (*OLLR*) = longitudinal ridges outer to *LLR*.

Chaetae. Collar chaetal fascicles usually consist of two types of chaetae, *special collar chaetae* (= "Les soies speciales du 1er sétigère" [Zibrowius, 1968]) or "*special chaetae*" (ten Hove & Zibrowius, 1986), and *simple blades*, the latter also referred to in the literature as *simple limbate chaetae*, or *capillaries* when a blade is not clearly discernible or lacking. The terms *special collar chaetae*, *simple blades* and *capillaries* are employed in the descriptions which follow.

The structure of special collar chaetae is recognized by authors to be characteristic for various taxa. Those described as being *bayonet-shaped chaetae* occur among taxa belonging to the genera *Pomatostegus, Spirobranchus*, and in the subfamily Serpulinae *sensu stricto*. Taxa belonging to the latter frequently but not always bear a number of conspicuous teeth on the boss of the chaetal shaft; as shown by ten Hove & Weerdenburg (1984: 148–149) they possess an unserrated notch between the boss of the chaetal shaft and blade. In contrast, an unserrated notch is absent between the boss and the blade in *Spirobranchus*.

Although collar chaetae had frequently been described and figured under optical microscopes as being merely serrated, mostly along one plane, the actual arrangement of the serrations is more complicated, as seen, for example, in SEM of notochaetae from the 1st and 2nd thoracic segments of the serpulid *Paraprotis dendrova* Uchida, 1978, by Nishi (1992: figs B and C, respectively) and ten Hove & Kupriyanova (2009: figs 17A, 20A).

The unmodified thoracic notochaetae in serpulimorphs have sometimes been termed 'hooded' chaetae. For example, ten Hove & Nishi (1996: 89) describe them in *Spirobranchus corrugatus* as being narrowly hooded (capillaries) in the collar fascicle, and broadly hooded (limbate) in the remaining thoracic chaetigers. It is not always easy to make distinctions between the two types, and since intermediate forms frequently occur, the terms are not used in this paper.

Some posterior thoracic chaetigers in certain serpulimorph taxa bear chaetae which have been referred to by various authors as *Apomatus*-chaetae, chaetae of *Apomatus*, sickle-shaped chaetae, or simply as sickles. They are referred to as sickle-shaped chaetae or sickles in the following descriptions to avoid having to liken them to chaetae occurring in another genus, namely *Apomatus*.

Apron. In many serpulid taxa the dorsally occurring thoracic membranes of the two sides extend past the last pair of thoracic chaetigers and unite ventrally as a transverse membraneous flap across the anterior abdominal segments, aptly termed "apron" by ten Hove & Weerdenburg (1984: 158).

Other abbreviations: AM = Australian Museum, Sydney; AM W = prefix for AM registration numbers; NHM = Natural History Museum, London; BMNH = prefix for British Museum (Natural History) registration numbers; ZMK = Zoological Museum, København (Copenhagen).

Reference to figures in the present document begin in upper case, e.g., Fig. 12; reference to other figures begin in lower case, e.g., Pillai, 1961: fig. 12.

Systematic account

The scheme for dividing serpulimorph polycheates into three subfamilies, namely, the Serpulinae, Filograninae, and Spirorbinae under the Serpulidae, and which had been used by some authors recently, is essentially Fauvelian. On the basis knowledge available at that time, Fauvel (1927: 346–403) includes widely different genera such as *Serpula, Mercierella* (presently *Ficopomatus*), *Vermiliopsis, Pomatostegus, Placostegus, Pomatoceros* and *Ditrupa* under the Serpulinae (pp. 350–375); those included under the subfamily Filograninae (pp. 375–387) are *Filograna, Salmacina, Josephella, Protula* and *Apomatus*, while the Spirorbinae consists of the single genus *Spirorbis* divided into subgenera.

However, research on serpulids carried out by numerous scientists during the period of over eighty years since then, had resulted in accrual of a vast amount of knowledge on them and alternative schemes for their classification, and there appear to be no sound reasons for reverting to Fauvel's (1927) classification rather than moving on, on the basis of knowledge available since then.

An important morphological character that needs to be taken into consideration with regard to classification of serpulids in general is that of opercular insertion. Although ten Hove (1984: 184–189) did not categorically state that the operculum in all serpulimorphs is derived from the second dorsalmost branchial radiole, his arguments regarding it in certain taxa, supported by drawings, could, perhaps, lead one to such a conclusion. Indeed, Fitzhugh (1989: 11) concludes that "ten Hove (1984) has shown that the serpulid operculum is actually a modified second, dorsalmost radiole. It is only in large-bodied serpulid species that the opercular stalk migrates during development to a position, which causes it to appear as though it originates from the first radiole." Rouse (2000: 187) came to the same conclusion: "ten Hove (1984) argued that in all serpulids the operculum is derived from the second most dorsal radiole, though its position may alter subsequently." However, this is, in reality, not the case with with all serpulids, as shown by Matjjašic & Sket (1966), Orrhage (1980) and Pillai (2008, 2009).

In the latter context, Fauvel's inclusion of *Protula* under the Filograninae causes some problems. According to Kupriyanova & Jirkov (1997), in *Protula*, an operculum, when present, is vesicular and occurs in the position of the second branchial radiole, whereas *Filograna* has "two spoon-shaped opercula on the first non-modified pinnulate branchial radioles, one on each branchial radiole". Likewise, Fauvel's subfamily Serpulinae includes genera, such as, *Serpula* and *Spirobranchus* in which the operculum is inserted in the position of the second radiole as well as those, such as, *Ditrupa, Vermiliopsis, Pomatostegus* and *Mercierella* (currently *Ficopomatus*) in which it inserted in the position of the first radiole.

Uchida (1978) erects several new serpulid subfamilies, the acceptance of which has been met with some reticence. However, it is to be expected that adequate scientific reasoning be provided in the event of acceptance or non-acceptance any of his specific proposals. In the meantime, classification of the Family Serpulidae into subfamilies in this paper is limited to a few that could adequately be explained and accepted in terms of the International Rules for Zoological Nomenclature. In the latter context, the subfamily Serpulinae, Macleay, 1840, *sensu stricto* is used for genera that constitute the *Serpula-Spiraserpula-Crucigera-Hydroides* clade.

The descriptions of taxa in this paper broadly follow current phylogenetically based serpulimorph classifications. Their groupings range from genera that are currently believed by various authors to be more primitive, e.g., the Filograninae, to those less primitive and possess either simple to complex chitinous opercula, or calcareous opercula, besides other characters.

They are dealt with alphabetically in two sections: the Kimberleys genera and species, followed by comparisons with species, especially of *Spirobranchus*, from other locations in Australia and the Indo-West Pacific. Within each genus, the species are dealt with in alphabetical order.

Subfamily Filograninae Rioja, 1923

Type genus. *Filograna* Oken, 1815.

Type species. *Filograna implexa* Berkeley, 1828. See Hartman (1959: 576), Kupriyanova & Jirkov (1997: 209), and Nogueira & ten Hove (2000: 151).

Diagnosis. Operculum absent, or present. When present, may be a terminal swelling at the end of each of several branchial radioles as in *Salmacina*, or modification of first branchial (dorsalmost) radiole, as in type genus, *Filograna*; neither chitinous nor calcareous. Peduncle pinnulate; inter-radiolar membranes absent or present; Maximum number of thoracic chaetigers high compared with less plesiomorphic taxa, even up to 12 or more. Thoracic membranes: absent or present; apron absent or present. Special collar chaetae consist of either simple blades only (i.e., lacking a fin-shaped basal part) or a blade and basal fin-shaped process. Posterior thoracic chaetigers may or may not bear sickle-shaped chaetae. Thoracic uncini either rasp-shaped only; or both rasp-shaped and saw-shaped. Abdominal neurochaetae: geniculate.

Remarks. As a group considered by most workers to be most plesiomorphic among serpulimorphs, the subfamily Filograninae currently includes taxa that are variable with regard to characters used to separate less primitive (more apomorphic) taxa. Notable among them are the presence or absence of an operculum, thoracic membranes, collar chaetae possessing a fin and blade, sickles in the posterior thoracic chaetigers, and an apron; also, whether thoracic membranes are absent, as originally described for *Salmacinopsis* or, present as in the new genus *Kimberleya* described in this paper.

The genera *Filograna* Oken, 1815, and *Salmacina* Claparède, 1870, had in the past been included under the Filograninae. McIntosh (1923) believed *Filograna implexa* Berkeley and *Salmacina dysteri* (Huxley) to be "synonymous on the grounds of their similarities in most respects and their frequent occurrence in the same mass of tubes. Fauvel (1930 & 1932) did not support McIntosh's view but distinguished the two genera on the basis that *Filograna* possesses a kind of operculum that is lacking in *Salmacina.*

Recently, Kupriyanova & Jirkov (1997: 209) distinguish the genera *Filograna* and *Salmacina* "by the presence of two (rarely one) membranous opercula in the former and the absence of the operculum in the latter." Furthermore, with regard to *Filograna* they also describe the occurrence of "Two spoon-shaped opercula on the first non-modified pinnulate branchial radioles, one on each branchial radiole." Nevertheless, following authors who consider operculate and non-operculate forms as being only different species within the same genus, they include *Salmacina* under the genus *Filograna.* Nogueira & ten Hove (2000: 151) who discuss the "*Filograna*/*Salmacina* complex" also characterize *Salmacina* as being non-operculate.

Kimberleya n.gen.

Type species. *Kimberleya hutchingsae* n.sp.

Diagnosis. Operculum absent. Radioles arise from a common base on each side, arranged semi-circularly; interradiolar membranes absent. Thoracic membranes present; apron present. Thorax consists of 10 chaetigers. Special collar chaetae: simple blades (devoid of a fin-shaped basal process). Sickle-shaped chaetae occur from 3rd to 10th thoracic chaetigers; uncinal tori occur from 3rd to 10th chaetigers; thoracic and anterior abdominal uncini rasp-shaped, their most anterior uncinal process simple and elongated; anterior abdominal chaetae geniculate.

Remarks. *Kimberleya* is unusual in that thoracic uncinal tori occur from the second pair of chaetigers onwards, unlike in other Filograninae and serpulid genera in which they occur from the third pair of thoracic chaetigers onwards. Furthermore, sickle-shaped chaetae occur from the 3rd to 10th thoracic segments.

Although sickle-shaped chaetae also occur from the 2nd or 3rd thoracic segment onwards in the genus *Pseudovermilia* Bush, 1907, there are other characters by which the two genera can be distinguished. *Kimberleya* lacks an operculum, possesses 10 thoracic chaetigers, an apron, and rasp-shaped uncini, whereas *Pseudovermilia* possesses an operculum, (incidentally, occurring in the position of the second branchial radiole unlike in other Filograninae where, when present, it is in the position of the first), 7 thoracic chaetigers, saw-shaped thoracic uncini, and lacks an apron.

Kimberleya is also similar to the genus *Protula* Risso, 1826, which has recently also been referred to as a *Protula*/*Apomatus*-complex, with regard to the following characters: absence, sometimes, of an operculum, possession of simple collar chaetae, sickle-shaped chaetae, rasp-shaped uncini with an elongated anterior process, an apron, and geniculate anterior abdominal chaetae. However, *Kimberleya* possesses 10 thoracic chaetigers, unlike *Protula* which possesses 7.

As in *Kimberleya*, an operculum is absent in the following genera: *Subprotula* Bush, 1910, *Floriprotis* Uchida, 1978, *Paraprotis* Uchida, 1978, and *Microprotula* Uchida, 1978. However, unlike *Kimberleya*, they all possess 7 thoracic chaetigers.

Kimberleya hutchingsae n.sp.

Fig. 2A–G

Type material. Kimberleys, Western Australia. HOLOTYPE, AM W21396, E side of Fenelon Isl. 14°0'S 125°43'E, 18 Jul. 1988, St 64. PARATYPES, AM W21447, juveniles, reef NW of Buffon Isl. 14°55'S 124°E, 20 m, 23 Jul. 1988, St 85; all collected by P.A. Hutchings.

Description

Measurements. Holotype: Diameter of anterior part of tube 1.0 mm; lengths of worm 9.8 mm; branchial radioles 1.2 mm, thorax 1.2 mm, and abdomen 7.4 mm; width of thorax 0.5 mm. Paratypes: both juveniles with their branchial crowns missing; maximum external tube diameter 0.6 mm; thoracic width 0.25–0.3 mm; length of abdomen 3.0–3.5 mm.

Tube. White, almost circular in cross-section, with free anterior end, coiled upon itself and bonded together where they lay upon each other (Fig. 2A). Surface bears fine transverse markings, with granular overlay, especially along ridges and laterally; anteriorly, bears a pair of faint, broad, smooth, longitudinal ridges; a shallow lateral longitudinal groove recognizable along each side. Tubes of paratypes very small, white, coiled (Fig. 2G), with translucent granular overlay.

Worm. Holotype: operculum and rudimentary operculum absent (Fig. 2B). Radioles number 6 on each side, their pinnule-free tips short and similar in diameter to those of pinnules. A pair of prostomial eyespots present, each consisting of several reddish ocelli. Thorax possesses 10 chaetigers. Abdomen (Fig. 2B) possesses about 115 segments; capillaries occur from about segment 102 to end of abdomen; abdominal tori short, lateral. Both paratypes: juveniles, radiolar crowns missing; possess more than 7 thoracic chaetigers, adult number not yet attained; although difficult to discern, a very narrow apron present.

Chaetae. Holotype: first and second thoracic chaetigers bear only notochaetal fascicles consisting of simple serrated blades (Fig. 2C), but lack neurochaetal uncinal tori. Third to 10th thoracic chaetigers bear notochaetal fascicles as well as neurochaetal uncinal tori; their notochaetal composition as follows: 3rd and 4th fascicles, 3 simple blades + 2 transitional sickles (Fig. 2D); 5th, 3 simple blades + 1 transitional sickle; 6th, 3 simple blades + 3 (fully formed) sickles (Fig. 2E); 7th and 8th, 4 simple blades + 4 (fully formed) sickles; 9th, 4 simple blades + 3 (fully formed) sickles; 10th, 4 simple blades + 2 (fully formed) sickles. Thoracic as well as anterior and posterior abdominal uncini: rasp-shaped (Fig. 2F). Paratype: similar to holotype in lacking neurochaetal uncinal tori in its first and second thoracic chaetigers.

Remarks. *Kimberleya* is quite unusual among serpulids in that its first two thoracic chaetigers bear notochaetal fascicles and lack uncinal tori, whereas only the first thoracic chaetiger bears notochaetal fascicles and lacks uncinal tori in the other genera.

Etymology. The type species is dedicated to Dr Patricia Hutchings of the Australian Museum, Sydney, who made this interesting collection of serpulids from the Kimberleys of Australia, besides her many other efforts and contributions to our knowledge of the Polychaeta.

Genus *Protula* Risso, 1826

Type species. *Protula tubularia* Montagu, 1803. See Ben-Eliahu & Fiege (1996: 27).

For synonymy of genera see Fauvel (1927: 381).

Erratum. On page 98, the author intended that the paragraph beginning: "**Remarks.** *Kimberleya* is quite ..." printed at the end of the *K. hutchingsae* description, replace a paragraph beginning "**Remarks.** *Kimberleya* is unusual ..." originally printed under the generic diagnosis. [Editor—3 Dec. 2009]

Diagnosis. Operculum absent or present; when present, occurs in position of second radiole; neither chitinous nor calcareous; peduncle pinnulate. Inter-radiolar membranes present. Thoracic membranes present; apron present. Thorax consists of 7 chaetigers; special collar chaetae simple, i.e., devoid of fin-shaped basal part; sickle-shaped chaetae present in posterior thoracic chaetigers; thoracic uncini rasp-shaped, their most anterior tooth simple; abdominal chaetae geniculate.

Remarks. Hartmann-Schröder (1996: 573) adopts the subfamily Protulinae Uchida, 1978. According to Bianchi (1981), however, the distinction between *Protula* and *Apomatus* based only on the presence or absence of an operculum is apparently unjustified, and there is a need of a world revision of *Protula* (= *Apomatus*). As stated also by ten Hove (1984), the genera *Apomatus* and *Protula* "are phylogenetically ill-defined." The difficulties in distinguishing between the two genera on the basis of criteria usually employed by taxonomists are again brought out by ten Hove & Pantus (1985), who deal with them as an *Apomatus/Protula* "complex". They also conclude that, in order to avoid further confusion, and until there is a full revision, one would have to abide by "the traditional use of *Apomatus* for operculate specimens, *Protula* for non-operculate specimens".

Although, in later studies, Ben-Eliahu & Fiege (1996: 27) provide a key to distinguish between species of *Protis, Apomatus* and *Protula* from the Levant Basin, Kupriyanova & Jirkov (1997:222) consider *Apomatus* and *Protula* to be synonymous. They define the genus *Protula* (including *Apomatus* Philippi, 1844) as possessing 7 thoracic chaetigers, an operculum, when present, that is vesicular and occurring in the position of the second branchial radiole, an apron, "simple limbate" collar chaetae, sickle-shaped chaetae in the thorax, rasp-shaped uncini, and abdominal neurochaetae with dentate or sickle-shaped blades. They also describe *Protula globifera* (Theel, 1876), a new combination, and as a synonym of *Apomatus globifer* Levinsen, 1887.

However, it is evident that other characters need to be considered in order to resolve their taxonomy. Firstly, the operculum in *Apomatus* occurs in the position first radiole, whereas, when present, it is in the second in *Protula*. Furthermore, although *Protula* possesses a pinnulate opercular peduncle as in the Filograninae, it differs from them in two additional characters, viz., in possessing a whorled radiolar arrangement and inter-radiolar membranes.

According to Kupriyanova & Jirkov (1997), the type species of the genus *Protula*, namely, *P. tubularia* (Montagu, 1803), possesses the following characters: branchial radioles varying in number from 15–50 pairs; a wide post thoracic ventral apron; simple collar chaetae; *Apomatus*-chaetae (= sickle-shaped chaetae in present paper) in posterior thoracic chaetigers; short anterior abdominal chaetae, distally curved and limbate (figure 10 F shows their geniculate bend), and rasp-shaped thoracic uncini, their most anterior tooth "long, simple not bifurcate."

Furthermore, differences between two species of *Protula*, namely, *Protula bispiralis* and *P. tubularia* are as follows: presence, in the former, of a central axis on which the radioles are spirally arranged in 3–10 whorls, in contrast with the latter in which the arrangement is semi-circular. This difference has been well described and illustrated by Day (1967: 818–820, figs 37.7k–n, 38.7o–r).

The present paper follows ten Hove (1994) who, based on the literature, states that the tropical Indo-West Pacific records can be roughly brought together under two taxa."One of them is *Protula bispiralis* with 3–8 whorls of spirally arranged branchial radioles and a tube diameter of up to two centimeters. The second is *Protulopsis nigranucha* (Fischli, 1900) which has "a semicircular arrangement of its radioles (at most in a ¾ spire), and with a tube of up to a few millimetres in diameter."

It is evident that ontogenetic studies relating to the following characters would be useful in the revision of the genus: the presence or absence of spirally arranged radioles and maximum number of spirals in relation to size, presence or absence of an apron, and whether the latter is present in juveniles and lost in adults.

Protula bispiralis (Savigny, 1820)

Serpula bispiralis Savigny, 1820: Paris, (3)21: 325–482.
Serpula bispiralis.—ten Hove, 1994: 107–116; Day, 1967 (2): 459–878; Straughan, 1967a: 251.
Protula magnifica.—Straughan, 1967b: 41–42.

Material examined. Kimberleys, Western Australia: 1 specimen, AM W202933, Rob Roy Reef, 14°26'S 124°52'E, 28 m, 4 Jul. 1988, st 49. 2 specimens, AM W21439, Lafontane Island, 14°10'S 125°47'E, 15 m, 9 Jul. 1988, st 68. 1 specimen, AM W21424, southwest corner of Lucas Island, 15°13'S 124°31'E, 30 m, 24 Jul. 1988, st 101. 1 specimen without tube, AM W21429, south side of Long Reef, 14°01'S 125°44'E, 20 m, 18 Jul. 1988, st 60; a total of 5 specimens, all coll. P.A. Hutchings.

Description

Measurements. Maximum external diameters of two largest tubes, respectively: 13.0 mm and 12.6 mm, their thicknesses, 1.5 mm and 1.3 mm, total lengths of two worms from AM W21439: 80.0 mm and 75.0 mm; their thoracic widths of 9.5 mm and 8.6 mm, respectively. Abdominal segments in two larger specimens number 155 and 159, with capillaries occurring from about 81st to 109th and 81st segments, respectively, until about 4 segments from their posterior ends.

Remarks. For a good species description, see Day (1967: 818). Accordingly, it attains very large sizes, up to a length of 180.0 mm, and there may be up to 10 whorls of radioles on each side arranged along a central axis, united for a third of their length by a web (= inter-radiolar membranes). The largest specimen in the Kimberleys collection is less than half that size; it has 4 radiolar whorls on each side. However, NHM collection 1905 BMNH 1924.6.13.181a contains very large specimen from Cargados Carajos, NE of Mauritius, Indian Ocean, collected by J.S. Gardiner, and identified as *P. bispiralis* by ten Hove. Although the worm is contracted in alcohol, and the radioles difficult to measure, the total length of the worm is well over 150.0 mm; its thorax is 60.0 mm long and 25.0 mm wide; its abdomen 05.0 mm long and its maximum width of 20. 0 mm; and nine radiolar whorls could be counted on each side. A specimen from South Africa, in NHM collection BMNH 1936.10.16.312, also has 9 whorls on each side.

The thoracic uncinal tori are in *P. bispiralis* apparently lost as the worms grow older. A similar situation also apparently prevails in *P. tubularia* from the Mediterranean, in which, according to Fauvel (1927: 381), their presence is not constant, occurring most frequently in smaller individuals and apparently totally lacking in larger ones. The thoracic membranes extend to the last thoracic chaetigers, but do not form an apron. Ontogenetic studies would help to confirm whether in *P. bispiralis* too an apron is present in juveniles and lost in specimens. Meanwhile, following ten Hove (1994), the above specimens are assigned to *Protula bispiralis*.

Distribution. Widely in the Indo-West Pacific (ten Hove, 1994).

Pseudoprotula n.gen.

Type species. *Pseudoprotula kimberleyensis* n.sp.

Diagnosis. Operculum absent. Thorax consists of 7 chaetigers. Special collar chaetae: simple blades (devoid of fin-shaped basal part). Sickle-shaped chaetae present in posterior thoracic chaetigers. Thoracic membranes present, terminate on 5th thoracic chaetiger; apron absent. Uncinal tori borne along posterior edge of a wide flap-like extension on each side. Thoracic uncini: rasp-shaped, their most anterior tooth simple and elongated. Abdominal chaetae: geniculate.

Remarks. All taxa presently considered to belonging to the "*Protula/Apomatus* complex" possess an apron. Some may or may not possess an operculum. *Pseudoprotula* lacks an apron.

Pseudoprotula kimberleyensis n.sp.

Fig. 2H,I

Type material. Kimberleys, Western Australia: HOLOTYPE: AM W202938, east Montalivet Island, 15°06'S 125°18'E, 6.0 m, 15 Jul. 1988, st 50; tube missing. PARATYPE: AM W29690, east Montalivet Island, 15°06'S 125°18'E, 6 m, 15 Jul. 1988, st 50, tube missing; coll. P.A. Hutchings.

Description

Measurements. Holotype (complete worm) total length 10.3 mm; width of thorax: 1.2 mm; length of abdomen 5.9 mm. Paratype: incomplete, lacks radioles; length without radioles about 15.5 mm; width of thorax 1.2; length of abdomen 10.5 mm. Holotype (Fig. 2H,I) with 11 radioles on left and 14 on right, pinnule-free tips short; its abdomen has 79 segments, with capillaries on about the last 30 segments. Paratype has 93 abdominal segments, with capillaries from about the 77th.

Tube. Missing in holotype and paratype.

Worm. Operculum absent; thorax with 7 pairs of chaetal fascicles; thoracic membranes broad and end on 5th chaetiger (Fig. 2I); first five thoracic uncinal tori on each side borne along posterior edge of a wide flap-like extension, posterolateral to its corresponding thoracic notochaetal fascicle; last uncinal torus on each side borne on a similar, larger, flap-like expansion. Corresponding flap-like expansions of the two sides not joined to form an apron (Fig. 2H).

Etymology. Named after the type locality, off the Kimberleys.

Genus *Vermiliopsis* Saint Joseph, 1894

Type species. *Vermiliopsis multivaricosa* Mörch, 1865 (= *V. infundibulum* Philippi, 1844), following Bush (1905: 233) and Zibrowius (1971, 1973b). Also see Fauvel (1927: 361) for synonymies.

Diagnosis. Operculum present; inserted in position of first branchial radiole; no rudimentary operculum; chitinous; bears transverse septa or other structural arrangements. Thoracic membranes extend along part of thorax; apron absent. Thorax consists of 7 chaetigers; special collar chaetae simple blades (i.e., lack fin-shaped basal part); sickle-shaped chaetae present in posterior thoracic chaetigers; thoracic uncini saw-shaped, their most anterior uncinal tooth simple; abdominal neurochaetae geniculate.

Vermiliopsis cylindrica n.sp.

Figs 3A–N, 4A–E

Type material. Kimberleys, Western Australia: HOLOTYPE: AM W21406, Lafontane Island, 14°10'S 125°47'E, 15 m, 19 Jul. 1988, st 68. PARATYPES: 3, AM W21471, south west corner of Lucas Island 15°13'S 124°31'E, 30 m, 24 Jul. 1988, st 101; 3, AM W21434, east of Montalivet Island, 15°06'S 125°47'E, intertidal, 6 m, 16 Jul. 1988, st 50; coll. P.A. Hutchings.

Non-type material. Kimberleys, Western Australia: 1 specimen, AM W21401, east side of Fenelon Island, 14°07'S 125°02'E, 6.0 m, 18 Jul. 1988, st 64, coll. P.A. Hutchings.

Description

Measurements. External tube diameter: from 4.3 mm in an adult specimen in AM W21471 to 0.6 mm in an early juvenile (Fig. 4D). Total lengths of worms: 25.3 mm in a specimen from AM W21471 to 6.5 mm in smallest juvenile. Thoracic widths: 2.5 mm to 0.5 mm in smallest available specimen in AM W21471. Length of operculum plus peduncle: 6.0 mm to 1.5 mm in smallest specimen. Length of operculum alone: 0.5 mm in smallest specimen to 2.5 mm.

Tube. White, mostly covered over by coral encrustation; difficult to remove without damage to ornamentation. Holotype (Fig. 3A) bears 5 longitudinal ridges in earlier formed posterior part, up to 7 anteriorly, where it is trapezoidal in cross-section. A juvenile paratype also bears 5 longitudinal ridges, although roughly circular in cross-section (Fig. 4A).

Worm. Radioles arranged in a semicircle on each side, their numbers ranging from 8 in a small juvenile to 22 in an older specimen; their pinnule-free tips club-shaped and thicker than pinnules; an early juvenile (Fig. 4E) has very few radioles on each side, somewhat swollen tips, and its operculum not yet developed. Operculum occurs on left or right side; rudimentary operculum absent. It consists of a bulbous proximal part and a chitinous distal part; the latter measuring 2.1 mm in a larger specimen, to 0.7 mm in a small juvenile. Chitinous distal part is characteristically cylindrical rather than conical; quite transparent (Fig. 3D,I,M); its diameter greater than its height, giving it the appearance of a circular pillbox, even in specimens with with a single partition (Fig. 3B–D,H,I). Maximum number of partitions few, up to about 4 or 5 (Fig. 3L–N). Terminal

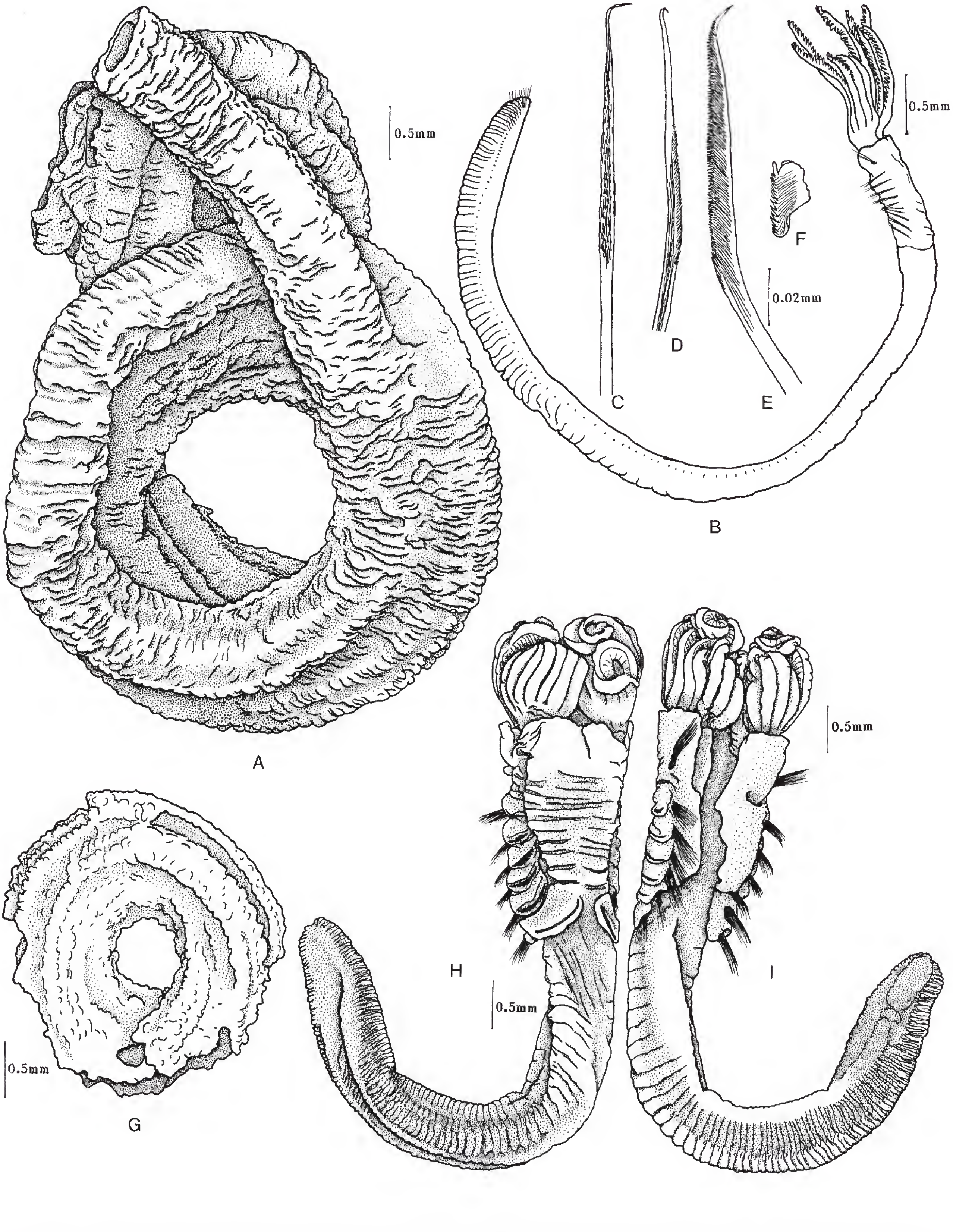

Figure 2. A–F, *Kimberleya hutchingsae* n.sp. from holotype AM W21396: (*A*) tube; (*B*) worm; (*C*) collar chaeta; (*D*) chaeta from the 2nd thoracic chaetal fascicle; (*E*) *Apomatus*-chaeta from a mid thoracic chaetal fascicle; (*F*) anterior abdominal uncinus (rasp-shaped); (*G*) portion of tube from AM W21447. H,I, *Pseudoprotula kimberleyensis* n.gen. and n.sp., from AM W202938, two views of complete worm: (*H*) ventral view of thorax showing the last pair of uncinal tori; (*I*) dorsal view of thorax: showing absence of an operculum, the number of thoracic chaetigers and the extent of the thoracic membranes.

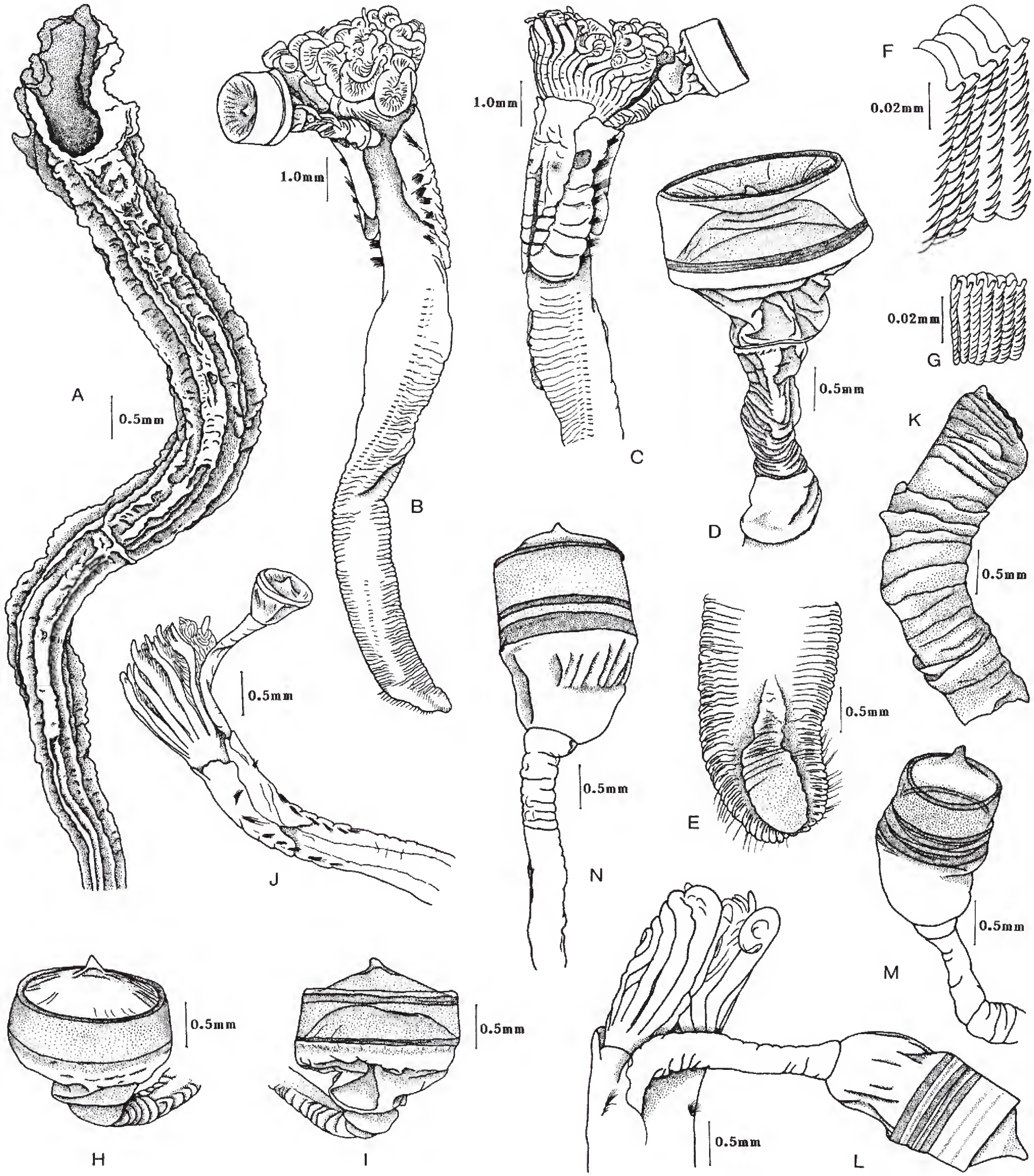

Figure 3. A–N, *Vermiliopsis cylindrica* n.sp. (*A*) tube of holotype, AM W21406; B–G, a specimen from AM W21434: (*B*) whole worm, showing its short and broad chitinous operculum, its cap contracted into a concavity, with a central peak, and the extent of the thoracic membranes; (*C*) left ventrolateral view of thorax showing the ocellar cluster, termination of the thoracic membrane, the contracted proximal bulb-like part of the operculum, the peduncle, and numerous radioles; (*D*) enlarged drawing of operculum showing its transparent chitinous distal part, a single chamber with its terminal part contracted into a concavity, and peduncle contracted into several irregular folds; (*E*) the cushion-like swelling (pygidial gland) at the posterior end of abdomen; (*F*) thoracic uncini; (*G*) anterior abdominal uncini; (*H,I*) two views of the operculum of specimen from AM W21434 showing an un-contracted dome-shaped distal part, a single transparent chamber below it, its contracted proximal bulb-shaped part (partly into the transparent chamber), and contracted peduncle; (*J*) anterior end of a small juvenile specimen showing operculum and extent of thoracic membranes; (*K*) tube fragment found together with a specimen from AM W21434 (doubtfully included here); confirmation necessary as to whether such a circular unattached part can occur in this species. L,M, specimen from AM W21434: (*L*) anterior end of worm; (*M*) operculum; both show an un-contracted proximal bulb-shaped part, and a cylindrical distal part, the latter consisting of 3 partitions preceding the terminal chamber; (*N*) operculum of a specimen from AM W21471: it is similar to that of the preceding specimen, but has two partitions proximal to the cylindrical chamber.

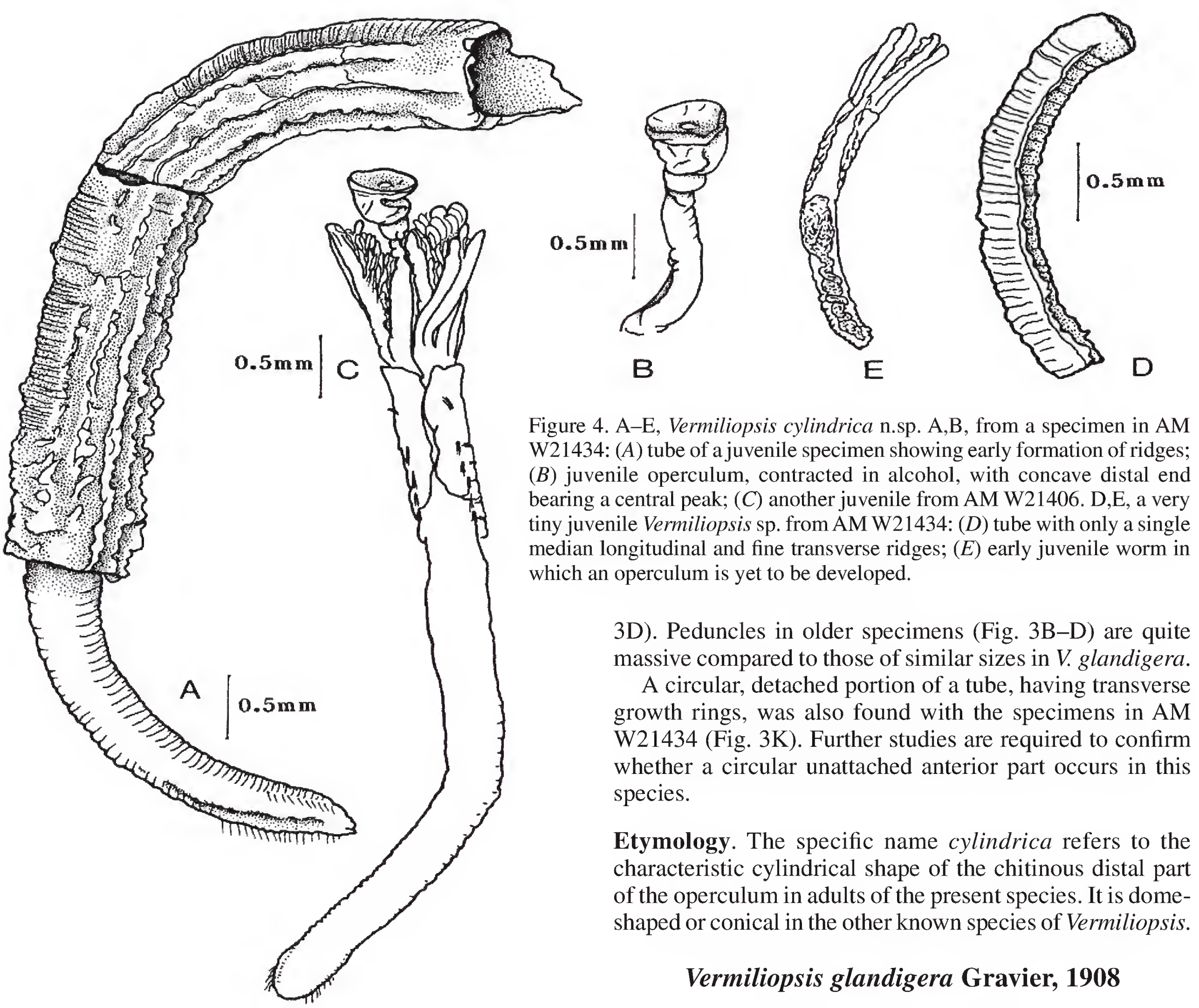

Figure 4. A–E, *Vermiliopsis cylindrica* n.sp. A,B, from a specimen in AM W21434: (*A*) tube of a juvenile specimen showing early formation of ridges; (*B*) juvenile operculum, contracted in alcohol, with concave distal end bearing a central peak; (*C*) another juvenile from AM W21406. D,E, a very tiny juvenile *Vermiliopsis* sp. from AM W21434: (*D*) tube with only a single median longitudinal and fine transverse ridges; (*E*) early juvenile worm in which an operculum is yet to be developed.

cap slightly convex, dome-shaped; bears a small peak in its centre in specimens unaffected in alcohol preservation (Fig. 3H,I,L–N). Both the terminal cap and peak may be collapsed into to a concavity in those affected by alcohol preservation, (Fig. 3B,D).

Chaetae. Chaetal composition as follows: those of first or collar fascicle similar to those of species described below; 2nd and 3rd thoracic chaetigers consist of bladed chaetae and capillaries; fourth consists of bladed chaetae, capillaries and transitional sickles (i.e., sickles commence on the fourth thoracic chaetiger); and 5th to 7th of bladed chaetae, capillaries and sickles. Each uncinal torus borne along the posterior border of a flap-like posteroventral extension of the thoracic wall (Fig. 3C); thoracic and anterior abdominal uncini saw-shaped (Fig. 3F,G); rasp-shaped in posterior part of abdomen; number of teeth in thoracic uncini 14 or 15; most anterior uncinal tooth simple, with a truncated tip (Fig. 3F,G).

Remarks. Microscopic examination of the early juvenile worm in which an operculum is yet to be developed (Fig. 4E), revealed the presence of sickle-shaped chaetae in the thorax.

The number of peduncular annuli is variable, a maximum number of about 10 is present in one specimen (Fig. 3I); less in another (Fig. 3N); not clearly formed in some (Fig. 3L,M), or even be irregular when highly contracted (Fig. 3D). Peduncles in older specimens (Fig. 3B–D) are quite massive compared to those of similar sizes in *V. glandigera*.

A circular, detached portion of a tube, having transverse growth rings, was also found with the specimens in AM W21434 (Fig. 3K). Further studies are required to confirm whether a circular unattached anterior part occurs in this species.

Etymology. The specific name *cylindrica* refers to the characteristic cylindrical shape of the chitinous distal part of the operculum in adults of the present species. It is dome-shaped or conical in the other known species of *Vermiliopsis*.

Vermiliopsis glandigera Gravier, 1908

Figs 5A–E, 6A–L, 7A–N

Vermiliopsis glandigerus Gravier, 1908: 121, pl. viii, figs 290, 291, text-figs 476–481.

Vermiliopsis infundibulum/glandigera-complex.—Fiege & Sun, 1989: 133, fig. 21A–E.

For further synonyms, see Fiege & Sun, 1989: 133–134.

Material examined. Kimberleys, Western Australia: 3 specimens, AM W21470, south west corner of Lucas Island, 15°13'S 124°31'E, 30.0 m, 24 Jul. 1988, st 101; 2 specimens, AM W21472, south west corner of Lucas Island, 15°13'S 124°31'E, 30.0 m, 24 Jul. 1988, st 101. Five specimens, AM W21451, reef north west of Buffon Island, 14°55'S 124°41'E, 20.0 m, 23 Jul. 1988, st 85; 1, AM W202948, Condillac Island, 14°06'S 125°33'E, sand with scattered bommies, intertidal, 6.0 m, 15 Jul. 1988, st 54. 1 specimen, consisting of operculum and radioles of right side only, AM W21427, south side of Long Reef, 14°01'S 125°44'E, 20.0 m, 18 Jul. 1988, st 60. 2 specimens, with tubes in fragments covered over by coral, AM W202957, Lafontane Island, 14°10'S 125°47'E, 15.0 m, 19 Jul. 1988, st 85. radiolar crowns and opercula only, AM W21407, Lafontane Island, 14°10'S 125°47'E, 15.0 m, 19 Jul. 1988, st 68; 2 specimens, AM W21450, reef north west of Buffon Island, 14°55'S 124°41'E, 20.0 m, 23 Jul. 1988, st 85. 1 juvenile, AM W21430, Condillac Island, 14°06'S 125°33'E, sand with scattered bommies, intertidal, 6.0 m, 15 Jul. 1988, st 54. 5 specimens, AM W21400, east side of Fenelon Island, 14°07'S 125°43'E, 18 Jul. 1988, st 64. 2 specimens, without tubes (one with incomplete abdomen, and the other with radioles and operculum of one side only) AM W21416, reef Northwest of Buffon Island, 14°55'S 124°41'E, 20.0 m, 23 Jul. 1988, st 85. 2 juvenile specimens, AM W21435, East of Montalivet Island, 15°06'S 125°18'E, intertidal, 6.0 m, 16 Jul. 1988, st 50; all coll. P.A. Hutchings.

Description

Measurements. External tube diameters: 0.5 mm in juveniles to 2.0 mm in older specimens. Total lengths of worms: 3.2 mm in a juvenile to 13.7 mm in a larger specimen; their thoracic widths: 0.7 mm to 0.2 mm, respectively. Lengths of operculum and peduncle range from 3.8 mm in an older specimen to 1.0 mm in smallest juvenile; length of abdomen up to about 7.5 mm, possibly longer in specimens not contracted in alcohol.

Tube. Shape: sinuous (Figs 5A, 6B,K) to loosely coiled (Figs 5C, 6I, 7I). Maximum number of longitudinal ridges observed 5 (Figs 5A,C). When sinuous, outermost ridge on each side, especially on concave side, extends laterally rather than vertically. Earlier formed posterior parts of tubes may have a smaller number of longitudinal ridges, e.g., 4 (Fig. 6B). Texture: mostly more or less pitted in longitudinal rows between ridges; may occasionally be quite smooth and shiny, with smooth ridges and hardly any pitting (Fig. 7I); or somewhat smooth-ridged and regularly pitted (Fig. 5C); older tubes roughly trapezoidal in cross-section, with a wide lateral flange along the substratum on each side, as seen in two latter specimens; a light brown inner tube lining often present. An unattached tube fragment, circular in cross-section, occurring in collection has peristome-like transverse ridges and some faint transverse ridges between latter (Fig. 7B). Further studies are necessary to confirm whether such an unattached portion occurs in this species.

Worm. Radioles semicircularly arranged; maximum number observed per side: 10 in an older specimen, 3 in smallest juvenile; pinnule-free tips ⅛ to ⅑ the total length of the radioles, usually slightly thicker than the pinnules (Figs 5A,B,D,E, 6J–L, 7C–E,G,N); up to about thrice as thick as pinnules in some specimens. Determination of opercular insertion difficult in adult worms; ontogenetically, however, it occurs in position of first, as seen in juveniles (Fig. 7D,E,M,N); may occur on the left or right side; rudimentary operculum absent. In older specimens, consists of a bulbous transparent to translucent basal part, and a conical transversely partitioned distal cap of chitin-like material (Figs 5A,B, 6C–E,I–L, 7A,C–E,G,H); latter translucent to semi-translucent, light to somewhat darker-brown in colour. Number of partitions ranges from none in the smallest juvenile (Fig. 7D,K,M,N), to 9 in one of the older specimens (Fig. 5A); however, maximum number could be much higher, 16, (Fig. 7A). Variations in opercular shape in alcohol-preserved material: as follows. Terminal cap in early juveniles frequently collapsed into a concavity with a small convex peak at its centre (Fig. 7C–E,K,M,N). Likely, however, to be dome-shaped in live condition, as seen in less contracted juvenile operculum (Fig. 7G,H); may be relatively unaffected (Fig. 5A,B), or collapsed to various extents in older specimens too (Figs 5D,E, 6J–L). Basal bulb-shaped part of operculum may also may retain its original form (Figs 6K,L, 7K,M,N), or be affected to various extents (Figs 5A,B,D, 6C–E,7A,C,D,G,H,J). Peduncle bears up to about 5 annuli distally, most distal one conspicuously large; may be relatively unaffected in alcohol preservation (Figs 6J,L, 7A,E,G,H,M,N); or, frequently, assume a very characteristic ventrally directed projection (Figs 5E, 6C,D).

Thorax bears 7 pairs of chaetal fascicles and 6 pairs of uncinal tori (Figs 5B,E, 6D,J,L, 7J). Thoracic membranes extend to fourth or fifth chaetiger only (Figs 5D, 6D,J,L, 7C–E,G); apron absent. Total number of abdominal segments varies from 32 in the smallest specimen available to 66 in an older specimen; capillaries in latter specimens start from segments 23 and 51, respectively; pygidial gland absent.

Chaetae. Chaetal composition of one side of thorax in longest worm as follows. Collar fascicle bears about 6 simple chaetae with curved serrated blades (Fig. 6F) and a similar number of capillaries; 2nd and 3rd fascicles, bear curved serrated blades only; 4th to 7th bear serrated blades chaetae and sickle-shaped chaetae, the latter numbering 2, 5, 3 and 3, respectively. Thoracic uncini: saw-shaped (Fig. 6G); bear about 12 teeth and a simple anterior; anterior and posterior abdominal uncini rasp-shaped (Fig. 6H). Anterior abdominal neuropodia frequently bear a single geniculate chaeta each, with a serrated blade; posterior ones bear 2 such chaetae.

Ontogenetic observations. The small juveniles in collection provide data on early development of tube, besides derivation and later development of the operculum and number of branchial radioles. The circular juvenile tube condition is shown in Fig. 7K, which then develops a MLR (Fig. 7L). A LLR is then added on, e.g., as seen toward the posterior end of the tube in Fig. 7I. Then, an OLR is added on each side, bringing the total to 5 as shown in Fig. 7F,I. Their form and number may or may not be distinct along parts of the tube (Fig. 6K).

As seen in the earliest available juvenile, the operculum is shaped like an inverted bell, terminating in a transparent to translucent chitinous plate (Fig. 7K,M,N). A faint constriction is discernible distally, between the vesicular part and the chitinous plate. At the centre of the latter is a tiny transparent to translucent swelling or peak. The first peduncular annulus is developed just beneath the vesicle (Fig. 7M). Two such annuli are seen in a later juvenile (Fig. 7C,D). It also bears a somewhat more prominent peak at the centre of the latter. In the next stage (Figs 6C–E, 7G,H), the operculum has changed shape, its chitinous part becoming somewhat conical, and its distal plate more like a cap, and its peduncle developing more annuli, most of them partially formed. An additional partition is noticeable in the cap (Fig. 7H).

The early juvenile operculum of *V. glandigera* as described above goes through stages similar to those described for *V. cylindrica* (Figs 3J, 4B,C), and it appears difficult to distinguish between the two species at this stage.

Remarks. The differences between *V. cylindrica* n.sp., and *V. glandigera* can be summarized as follows. In *V. cylindrica*, worms attain a larger size, as observed, up to a total length of about 25.3 mm, and possess a maximum number of 22 branchial radioles, which is about double that in *V. glandigera*. The chitinous distal part of the operculum in older specimens of *V. cylindrica* is cylindrical, its diameter greater than its height, which gives it a cylindrical pillbox shape transparent and may bear from 1 to about 5 light-brown bands encircling it.. In *V. glandigera*, on the other hand, it is conical in shape, and the maximum number of transverse partitions encountered is much higher, up to 16 observed in the Kimberleys collection (Fig. 7A). Thoracic uncini in *V. cylindrica* bear about 14–15 teeth and a truncated anterior process (Fig. 3H), whereas the number in *V. glandigera* is somewhat lower, about 12, and its anterior process is pointed (Fig. 6G).

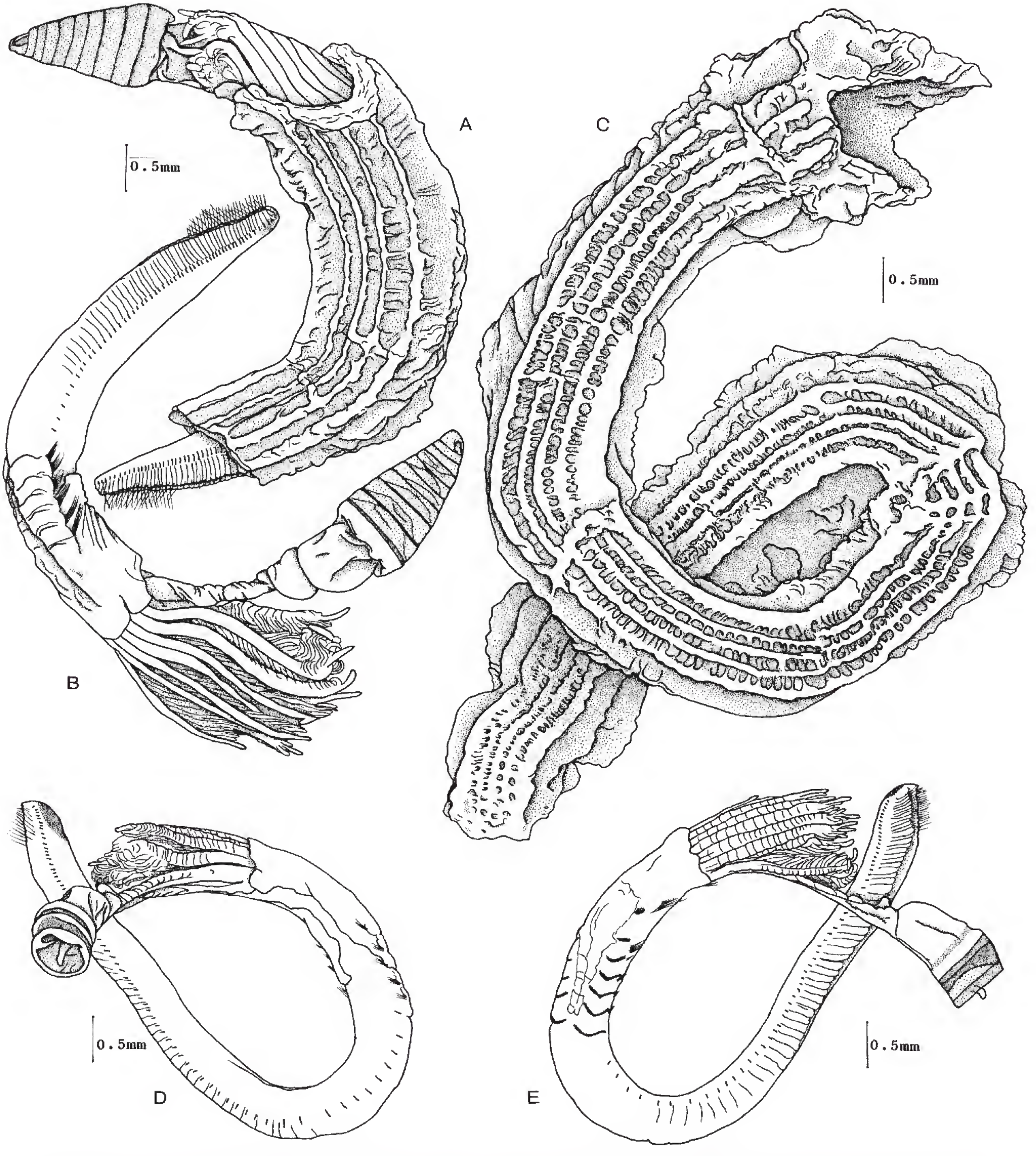

Figure 5. A–E, *Vermiliopsis glandigera* Gravier, 1908, figured from two specimens from AM W21470; A and B from first specimen; C–E from a second specimen: (*A*) worm *in situ* within its tube; (*B*) worm removed from tube showing the transparent partitioned operculum, its bulb-shaped basal part, the conspicuous annulus just below the latter, pinnule-free radiolar tips and extent of the thoracic membranes; (*C*) tube; D,E, worm removed from its tube: (*D*) worm showing distal end of the chitinous part of the operculum contracted into a concavity, and bears a small digitiform process in its centre; (*E*) another view of worm showing the transparent distal part of the operculum; the large annulus at the distal end of the peduncle has assumed the shape of a ventrally directed projection in alcohol.

However, there have been problems concerning the separation of *V. glandigera* occurring in the Indo-West Pacific from the Mediterranean and North Atlantic species *V. infundibulum* (Philippi), 1844. This has been due to recognition of similarities between material originally described from the Red Sea as *Vermiliopsis glandigerus* (= *Vermiliopsis glandigera*) by Gravier (1908: 121) and the type species of the genus *Vermiliopsis*, as stated above, namely, *Vermiliopsis multivaricosa* Mörch, 1865 (= *V. infundibulum* Philippi, 1844), but not differences in tube structure.

Monro (1930: 211) identified material from the Gulf of Guinea, off the Northwest Atlantic coast of Africa, as *V. glandigerus*, and thought it probable that *V. glandigerus* Gravier, and a couple of other species "will prove to be simple varieties of *V. infundibulum*." Subsequently, authors working on *Vermiliopsis* from the Indo-West Pacific have

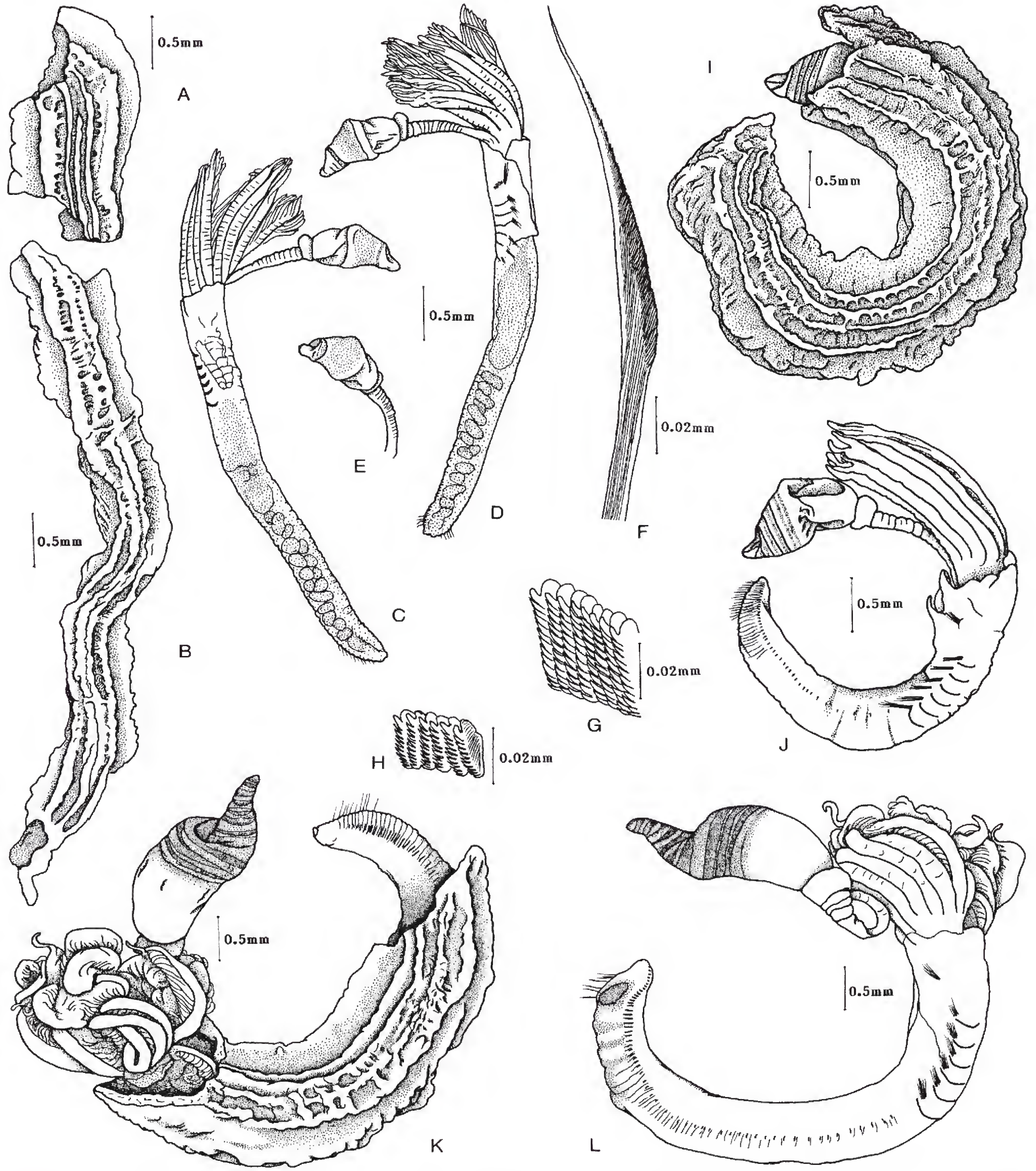

Figure 6. A–L, *Vermiliopsis glandigera* Gravier, 1908. A–E, a juvenile specimen from AM W21470: (*A,B*) portions of the tube; (*C,D*) two views of worm removed from tube. The operculum has few partitions, the enlarged peduncular annulus just below the operculum and the extent of the thoracic membrane of the left side are shown; (*E*) another view of the same operculum. F–H, chaetae of a specimen from AM W21470: (*F*) collar chaeta; (*G*) thoracic uncini; (*H*) anterior abdominal uncini. I,J, a specimen from AM W21451: (*I*) tube with worm within; (*J*) worm removed from tube showing the number of partitions in the operculum, the enlarged peduncular annulus just below the operculum, and the extent of the thoracic membrane on the right side. K,L, a specimen from AM W202948: (*K*), worm and tube *in situ*; (*L*), worm removed from tube; the operculum has 12 partitions, the peduncular annulus below the operculum is enlarged.

referred the two species to a "*Vermiliopsis infundibulum/glandigera*-group," e.g., Imajima (1976: 139; 1978: 57; 1979: 169), Imajima & Hove (1984: 59, 1986: 9), Ishaq & Mustaquim (1996: 182), Nishi (1996: 315); or to a "*Vermiliopsis infundibulum/glandigera*-complex", e.g., ten Hove (1994: 113), and Fiege & Sun (1999: 133). Ten Hove (1994: 113) also draws attention to the difficulties in identifying species belonging to the "*Vermiliopsis infundibulum/glandigera*-complex", in referring to them as being "one of the most difficult complexes of serpulids".

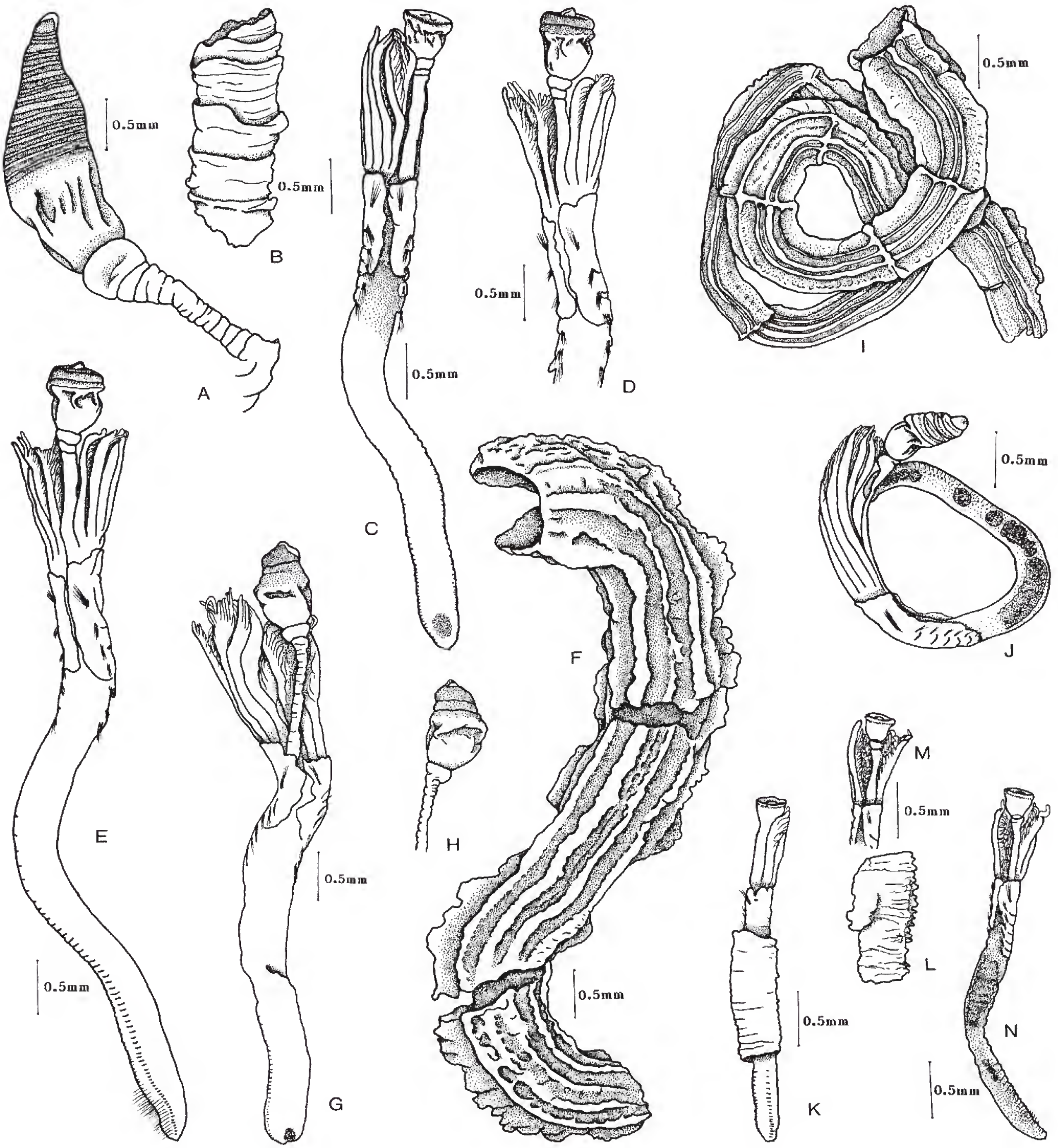

Figure 7. A–N, *Vermiliopsis glandigera* Gravier, 1908. (*A*) operculum of a specimen from AM W21470 with 16 partitions, including the terminal cap, and showing the characteristic enlarged terminal annulus of the peduncle; (*B*) part of a tube found with latter specimen, questionably, an anterior unattached part. C,D, Two juveniles from AM W21472; (*C*) worm showing distal part of its operculum contracted into a concavity with a central peak, partitions not yet developed, annulus below its basal bulb-like part is already enlarged, and thoracic membranes extend to the 4th chaetiger; (*D*) anterior end of a juvenile worm from AM W21472: operculum has 2+ partitions, its distal cap-like annulus is contracted into a concavity, and bears a central peak; thoracic membranes extend to end of fourth chaetiger; (*E*) a specimen from AM W21472 having 3+ opercular partitions, its distal cap contracted into a concavity with a peak, and enlarged annulus at the distal end of its peduncle is discernible; (*F–H*) a juvenile specimen from AM W21472: operculum has an uncontracted dome-shaped cap with a peak, and three partitions; annulus at the distal end of its peduncle is enlarged. What appears to be a pygidial gland is faintly developed. I–J, a specimen from AM W21470: (*I*) tube, more regularly formed than in other specimens; smooth and shiny, not strongly pitted, has 3 smooth longitudinal ridges, besides the laterally extended one on each side, and well-formed transverse ridges (peristomes) at intervals. Worm (*J*) is indistinguishable from other specimens, including the swelling at the distal end of the peduncle. K–N, an early juvenile from AM W21470: (*K*) worm within part of its tube; (*L*) tube shows fine transverse ridges and a single irregularly serrated median dorsal ridge; (*M*) anterior end of worm; (*N*) whole worm; M,N, opercular cap contracted into a concavity and bears a rounded peak; the swollen distal annulus of the peduncle being developed.

Furthermore, based on past records of material identified as *V. infundibulum* (Philippi, 1844) from the Mediterranean to the Caribbean, Brazil, West and South Africa, Indian and Pacific Ocean by several authors, Zibrowius (1966: 376, 1968: 123) considered its distribution to be cosmopolitan. According to other studies, however, most of those earlier records outside the Mediterranean and the North Atlantic have been misidentifications.

It would, therefore, appear useful to compare what Monro (1930) identified as *V. glandigera* from the Gulf of Guinea with the Kimberleys material described above as *V. glandigera* in order to separate the two species that had been grouped together as the "*Vermiliopsis infundibulum / glandigera* complex" or "group" in the Indo-West Pacific.

An important character that had hitherto not been adequately recognized pertains to the peristomes occurring along the tube. They are considered here to be quite characteristic of *V. infundibulum*. Indeed, they are the only structures that could be recognized as being infundibular (funnel-shaped) and incorporated into its specific name by its author, Philippi, 1844. A concise and apt description is provided by Fauvel (1927: 363, fig. 124c): "*Tube calcaire, blanchâtre, épais, rapidment évasé, bourrelets en entonnoir*." Zibrowius's description (1966: 376/377) of tubes of of *V. infundibulum* collected from Madeira during the "Jean Charcot" Expedition is similar: "*Les tubes ... toujours pourvus de péristomes évasés*." In a later, more detailed study, Zibrowius (1968a: 122) confirms the presence of funnel-shaped peristomes along the tube of *V. infundibulum*, and adds the following: that it may be quite smooth or possess, frequently 4 or 5, or rarely 2 or 7, longitudinal ridges, but characterized by the "funnel-shaped" peristomes. The terminal peristome is always better developed and more outwardly directed than the preceding ones. A smooth tube with vase-shaped peristomes is figured and described by Bianchi (1981: 72, fig. 25a; see Fig. 8B in present paper). However, the tube fragment figured by Monro (1930: fig. 88c; see Fig. 8C in present paper) fits neither that of *V. infundibulum*, nor of *V. glandigera* described from the Kimberleys, but of another species. The terminal annulus of the opercula figured by Monro (1981: fig. 88a) is also different from that of *V. glandigera* from the Kimberleys.

The more important characters that distinguish *V. infundibulum* and *V. glandigera* can therefore be summarized as follows.

Differences between *Vermiliopsis infundibulum* and *Vermiliopsis glandigera*

In *Vermiliopsis infundibulum*, tubes bear characteristic massive funnel-shaped to vase-shaped peristomes with thickened outwardly directed rims; may be smooth or bear a number of longitudinal ridges but bear the characteristic peristomes; terminal peristome always better developed and outwardly directed than preceding ones. Worms attain maximum lengths of up to 30.0 mm; possess up to 20 radioles. Operculum could exceed 8.0 mm, chitinous, brown; more or less transparent; may possess up to 70 partitions. Thoracic uncini may possess up about 16 teeth; most anterior tooth longer than rest, simple. Number of abdominal segments may exceed hundred. See Zibrowius (1968a: 121–123).

In *V. glandigera*, on the other hand, tubes may be flared outwards on the substratum, but do not possess vase-shaped or funnel-shaped peristomes (Figs 5A,C, 6A,B,I,K, 7F,I). Indeed, such vase-shaped or funnel-shaped peristomes have not been described for the "*V. infundibulum/glandigera*-group" recorded from various localities in Indo-West Pacific. Instead, peristomes, when present, consist of thickened transverse ridges. A number of longitudinal ridges usually present. As regards Fig. 7B, even if such erect terminal portions of tubes are confirmed to occur sometimes in *V. glandigera*, their peristomes are not comparable to those of *V. infundibulum* (Fig. 8A,B). Worms: attain lengths of up to about 13.7 mm. Maximum number of radioles observed: 10 on each side. Operculum and peduncle attain lengths up to about 3.8 mm; maximum number of partitions observed in chitinous distal part, 16. Thoracic uncini: bear about 12 teeth and a simple anterior process.Maximum number of abdominal segments observed 66. The maximum attainable size, number of branchial radioles on each side, and number of abdominal segments in *V. infundibulum* is, therefore, about double that of *V. glandigera*. The maximum number of opercular partitions observed in former is about four times that of the latter. The number of teeth in the thoracic uncini is also higher.

Zibrowius (1968a: 123) gives the distribution of *V. infundibulum* as the Eastern Atlantic and Mediterranean, it's having been reported from Angola, Azores, Canaries, numerous locations in the Mediterranean, and the Black Sea. The latter distribution, the characters of *V. infundibulum* discussed above, and Monro's (1930) tube fragment (Fig. 8C) and opercula confirm that Monro's material from the Gulf of Guinea was not *V. glandigera*. *Vermiliopsis infundibulum* can now be, therefore, eliminated from the Indo-West Pacific. Past identifications of collections from the Indo-West Pacific as the latter may now be referred to *Vermiliopsis glandigera* Gravier, 1908, or other species of *Vermiliopsis*, as appropriate.

Ten Hove & Kupriyanova (2009: 100) provide an important discussion in this context. They use the name of the type species of genus *Vermiliopsis* Saint-Joseph, 1894, namely, *Vermilia multivaricosa* Mörch, 1861, as the new name for *Vermilia glandigera sensu* Philippi, 1844. Since *Vermilia* has been replaced by *Vermiliopsis*, the "*Vermiliopsis infundibulum/glandigera*-complex" or "group" discussed above would change to "*Vermiliopsis multivaricosa/ glandigera*-complex" or "group". Ten Hove & Kupriyanova, (2009: 102) refer to *V. infundibulum* as part of a complex with *V. pygidialis* and *V. glandigera* in the Indo-West Pacific.

Indeterminate species of *Vermiliopsis* reported from the Indo-West Pacific

Imajima (1976) describes material from Southwest Japan as "*Vermiliopsis infundibulum/glandigera* group." It attains nearly twice the size of *V. glandigera*, the largest worm having a total length of 25 mm and 109 segments and 18–19 pairs of branchial radioles. Moreover, it bears *Apomatus*-chaetae from the third thoracic chaetiger onwards i.e., the 3rd to 7th thoracic chaetigers, and the thoracic uncini bear 15–17 teeth. Quite interestingly, and as specifically described and illustrated by Imajima (fig. 11a,c–g), "several dark brown rings". Such pronounced dark rings or bands were not reported for *V. glandigera* by Gravier, 1908, are not obvious in the Kimberleys specimens, and have not been described in other collections identified as the "*Vermiliopsis infundibulum*

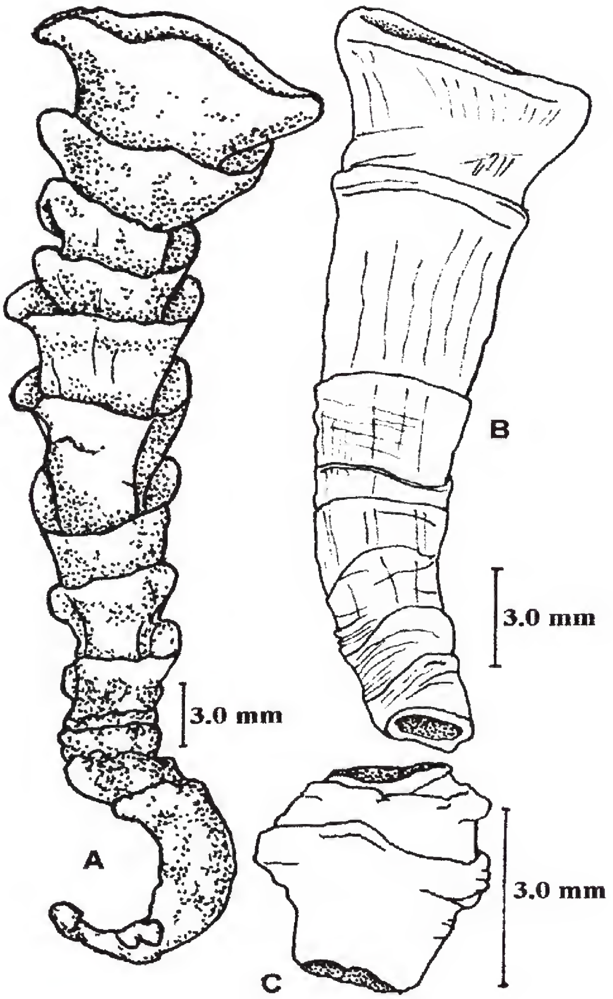

Figure 8. A and B, tubes of *V. infundibulum*. (*A*) after Fauvel (1927: fig. 124c), magnified about 4 times that of Fauvel's figure which represented its natural size. It also shows ontogenetic changes in which the earliest formed part abruptly increases in diameter and develops the vase-shaped peristomes, already bearing 11 of them in the tube of approximately 48.0 mm in length; (*B*) after Bianchi (1981: fig. 25a), same size as original figure; evidently an older tube compared to A; note the well-formed terminal peristome and thickened edges. (*C*) After Monro (1930: fig. 88c), same size as original figure; tube fragment figured by Monro as belonging to *Vermiliopsis glandigera* Gravier, 1908. Note that none of three types of tubes A–C occur in *V. glandigera* described from the Kimberleys.

/glandigera group" from the Indo-West Pacific. Further work is necessary to determine whether Imajima's specimens from Southwest Japan belong to a hitherto un-named species.

Fiege & Sun (1999: 133–136, fig. 21) describe material from the South China Sea as belonging to the "*Vermiliopsis infundibulum/glandigera* group". Since only anterior fragments were available, or they were retracted into their tubes, the authors did not provide the total length of the worm, numbers of radioles or the extent of the thoracic membranes. The opercula and their peduncles show similarities to those of Gravier's *V. glandigera* from the Red Sea, as well as the Kimberleys material belonging to the latter. They are also similar in not having sharply demarcated dark brown bands that are characteristic of the opercula of Imajima's species. However, the number of teeth in their thoracic uncini is around 15, whereas it is around 12 in *V. glandigera*. *Apomatus*-chaetae commence on the 3rd thoracic chaetiger in the South China Sea specimens, while they commence on the 4th in the Kimberleys specimens of *V. glandigera*. Data on the South China Sea specimens appear to be inadequate to determine whether they belong to *V. glandigera* or another species.

The material from Pakistan described by Ishaq & Mustaquim (1996: 182–183) as belonging to the "*V. infundibulum/glandigera* group" appears to possess some important differences from *V. glandigera*. The worms attain a total length of up to about 18.0 mm, the number of radioles is 10 to 12 on each side, thoracic membranes reach up to the end of the 4th thoracic chaetiger, *Apomatus*-chaetae occur from the 4th chaetiger onwards, and thoracic uncini have 10–12 teeth. Its description hitherto is similar to that of *V. glandigera*. However, there are significant differences. A maximum number of up to 114 abdominal segments have been observed in the material from Pakistan, as opposed to about half that number in *V. glandigera*. The most important difference is with regard to the operculum of the material from Pakistan, in which transverse partitions are absent even in worms larger than *V. glandigera*. Furthermore, Ishaq & Mustaquim describe the shape of the operculum as being ovoid to conical and, according their figure (fig. 11A) the dome-shaped horny opercular cap is blackish or black. The species is, evidently, neither *V. infundibulum* nor *V. glandigera*.

Genus *Pomatostegus* Schmarda, 1861

Type species. *Pomatostegus actinoceros* (Mörch, 1863)

Diagnosis. Operculum present, inserted in position of first radiole; chitinous, consists of a series of circular discs and circlets of spines transversely arranged along a central column; peduncle winged. Inter-radiolar membranes present. Thorax consists of 7 chaetigers. A pair of thoracic glands present, represented by a pair of ventrolateral slit-like apertures. Thoracic membranes end on third thoracic chaetiger; apron absent. Special collar chaetae: bayonet-shaped, boss serrated. Sickle-shaped chaetae present. Thoracic uncini saw-shaped, most anterior uncinal tooth simple; abdominal neurochaetae geniculate.

The genus is presently known to consist only of its type species. With its distribution apparently extending from the tropical western Atlantic to the Indo-Pacific it appears to be an ancient serpulid taxon.

Pomatostegus actinoceros (Mörch, 1863)

Figs 9A–E, 10A–E

Pomatostegus actinoceros Mörch, 1863.
Pomatostegus stellatus (Abildgaard, 1789).—Fiege & Sun (1999: 131–133, fig. 19), Imajima (1986: 9), Imajima (1977: 101–102), Straughan (1977: 1–102), Pillai (1960: 23, fig. 8F–I) and Dew (1959: 39, fig. 14).

Material examined. Kimberleys, Western Australia: 2 specimens from AM W21438, Lafontane Island, 14°10'S 125°47'E, 15 m, 19 Jul. 1988, st 68. 3 specimens, AM W202961, Long Reef, 13°58'S 125°38'E, 25 m, 17 Jul. 1998, st 58; 2 specimens, one an operculum only, AM W21452, reef north west of Buffon Island, 14°55'S 124°48'E, 20 m, 23 Jul. 1988, st 85. 1 specimen with an incomplete operculum, AM W21428, south side of Long Reef,

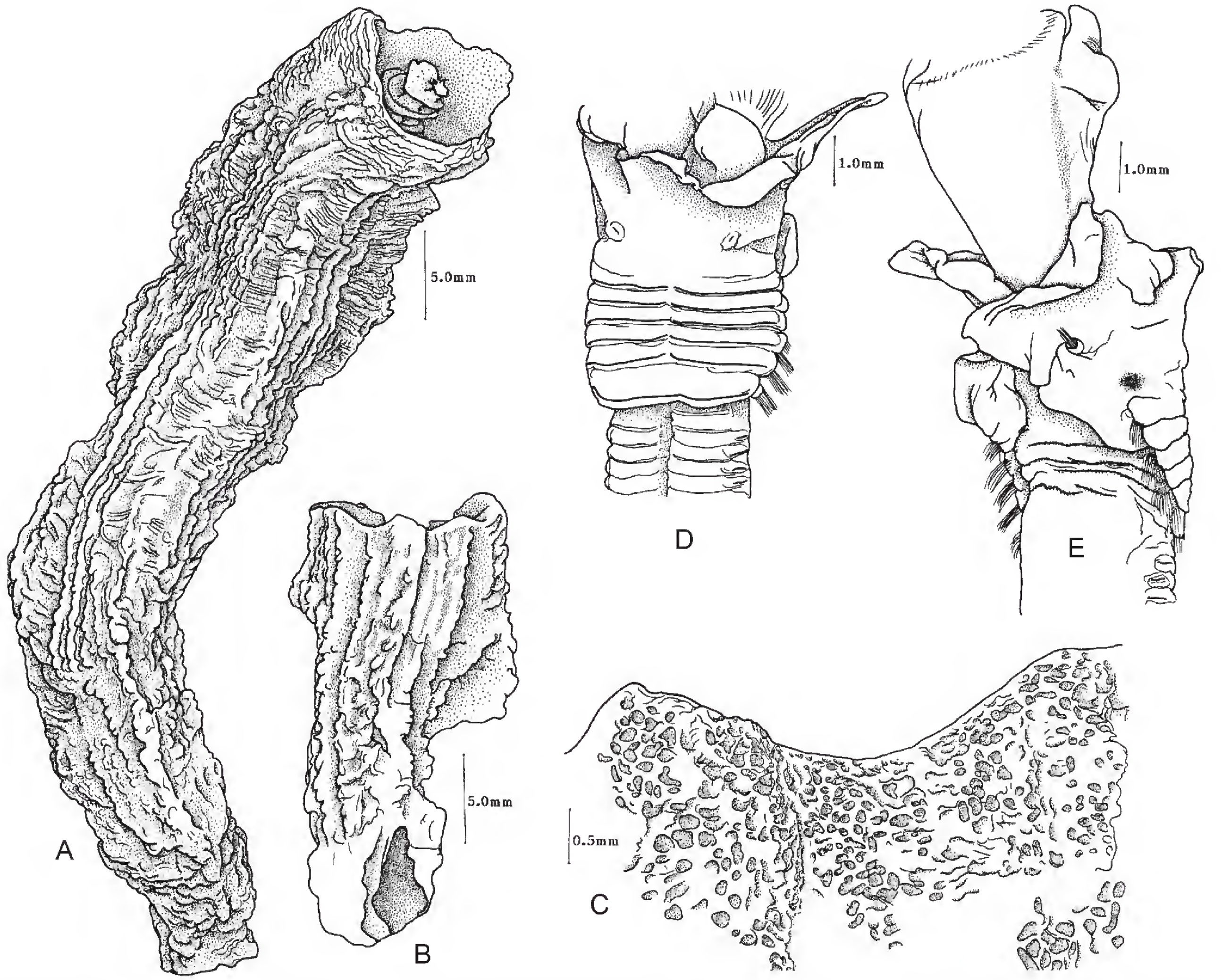

Figure 9. A–E, *Pomatostegus actinoceros*. (*A*) tube of a specimen from AM W21438. B–E, a specimen from AM W202961: (*B*) anterior part of tube; (*C*) drawing of magnified section of anterior part of tube to show the pitted surface; (*D*) ventral view of thorax; the slit-like apertures of the pair of thoracic glands are shown; an apron is absent, although the last of thoracic tori are continuous along the posterior edge of the thorax; (*E*) dorsal view of thorax; the unfringed peduncular wing and the prostomial ocellar cluster on the right side, as well as the thoracic membranes of the two sides of the 3rd thoracic chaetiger are shown.

14°01'S 125°44'E, 20 m, 18 Jul. 1988, st. 60. 1 large specimen, incomplete posteriorly from AM W21423, south-west corner of Lucas Island, 15°13'S 124°31'E, 30 m, 24 Jul. 1988, st 101; 1 specimen, AM 202947, Careening Rock, 15°06'S 125°06'E, sand, beach and rocks, intertidal, 13 Jul. 1988, st 41. 1 small incomplete specimen, AM W23093, Lafontane Island, 14°10'S 125°47'E, 15 m, 19 Jul. 1988, st 68: all coll. P.A. Hutchings.

Description

Measurements. Tube: maximum length of one with its posterior part missing: 85.0 mm; maximum external diameter of its posterior end, 8.2 mm. Worm: total length of longest available complete worm 48.0 mm; its maximum thoracic width 5.0 mm. Maximum abdominal length: 30.0 mm. Number of abdominal segments in relation to length variable: 102 for a specimen with abdominal length of 15.5 mm; 98 for a less contracted specimen with abdominal length 30.0 mm.

Tube. Creamish white to white, broadly semi-circular to obtusely triangular in cross-section; abruptly decreases in diameter posteriorly (Fig. 9A). Under higher magnification tube surface characteristically pitted (Fig. 9C). About 5 or 6 lateral longitudinal ridges may be present along each flank; a wide flange may be developed in places (Fig. 9A,B). A median longitudinal ridge may be more or less clearly developed; clearly seen in the posterior third of tube (Fig. 9A); fine transverse grooves may extend laterally from it (Fig. 9A).

Worm. Operculum on left or right side; peduncle fleshy and winged (Fig. 9E), bears a chitinous tiered distal part (Fig. 10A). Latter consists of a central column bearing circlets of dark outwardly directed spines at intervals, above each of which is a thin, shallow, translucent, yellowish-brown, saucer-shaped structure with a scalloped margin; marginal scallops not regularly shaped, but more or less rounded, flattened and their tips directed posterolaterally. Grooves extend between and along scallops to, or part of the way towards central column. Saucer-shaped structures may completely or partly damaged or lost in earlier formed distal tiers. Maximum number of tiers observed in collection 6. Maximum number of radioles observed per side, 58. Pair of slit-like apertures representing a pair of ventral thoracic glands present, (Fig. 9D). Pair of greyish/blackish pigment patches, apparently clusters of ocelli, discernible anterior to second pair of thoracic chaetal fascicles (Fig. 9E). Seven pairs of thoracic chaetal fascicles; thoracic membranes extend to of third pair of thoracic chaetal fascicles (Fig. 9E).

Apron absent. Last (6th) pair of thoracic uncinal tori located close together and meet, if not, almost meet mid-ventrally, and may have a very narrow flap posterior to them; when present, giving appearance of an apron (Fig. 9E).

Chaetae. Each bayonet-shaped chaeta (Fig. 10B) has a squarish basal boss and a long serrated blade, but lacks an unserrated notch. Thoracic uncini (Fig. 10C) possess 12 or 13 teeth in a single row and an anterior gouged process. Anterior abdominal uncinal tori are lateral (Fig. 9E) to somewhat dorsolateral, becoming more dorsolateral from about the 11th or 12th segment onwards. They are smaller than the thoracic uncini and bear 7 or 8 teeth in a single row (Fig. 10D). Posterior abdominal uncini (Fig. 10E) are still smaller but the number of teeth is somewhat higher, about 10.

Ontogenetic observations relating to operculum. One of the specimens provides evidence as to how opercular diameter increases in relation to increase in tube diameter as the worm grows in size (Fig. 10A). The earliest formed opercular tier is located at the distal end of the central column, and is the smallest in diameter. Each tier consists of a saucer-shaped part of light to darker coloured chitin-like material bearing marginal scallops and a circle of darker spines just beneath it arising from the central column. The newly formed saucer-shaped tier is of the diameter of the now larger distal end of the opercular plate. Both, the newly formed saucer-shaped plate and the circlet of spines of the earlier-formed saucer-shaped part are enclosed within a transparent membrane. The latter extends from a rim-like extension beneath the tier (X) to the rim of the opercular plate (Y). As the worm grows, larger tiers are produced successively by the opercular disc to keep pace with the increasing tube diameter, while the central column also extends in length.

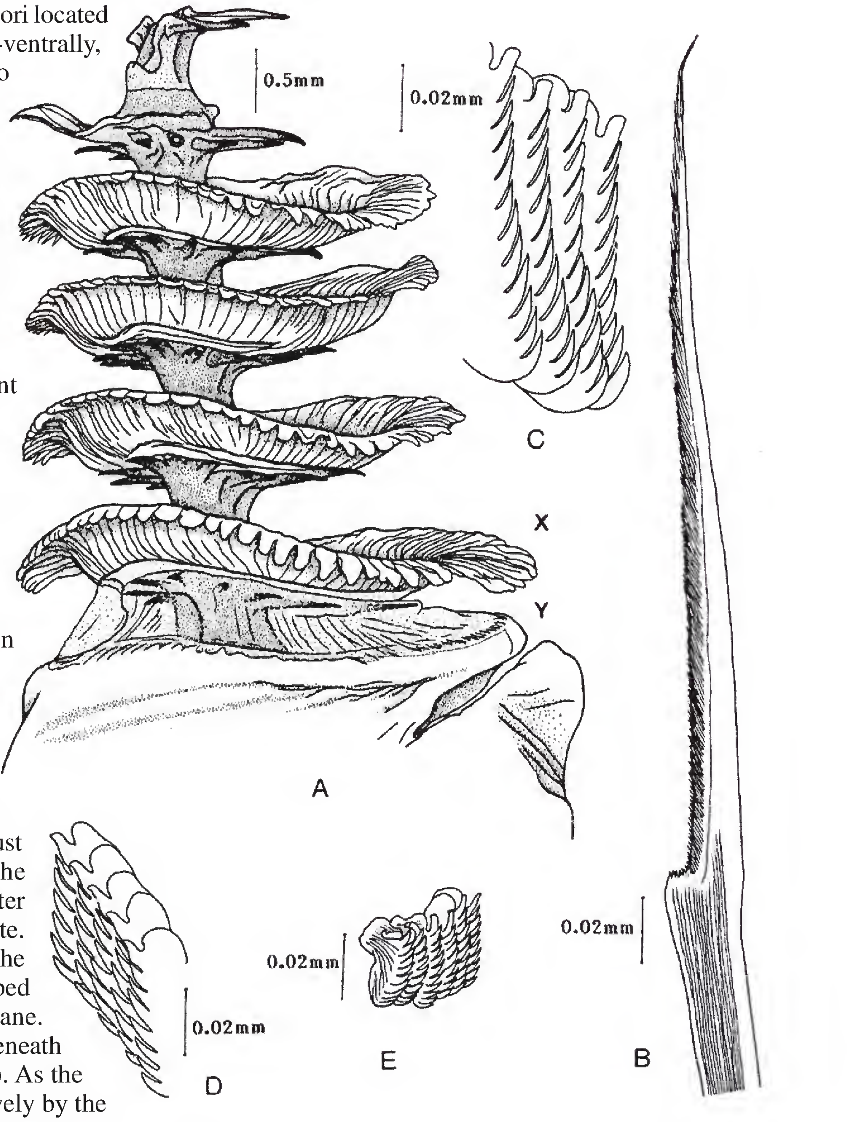

Figure 10. A–E, *Pomatostegus actinoceros*, specimen from AM W21438. (*A*) 6-tiered operculum, with the seventh in the process of being formed at the distal end of the fleshy part of the operculum (see text); (*B*) bayonet chaeta from the collar fascicle; (*C*) thoracic uncini; (*D*) anterior abdominal uncini; (*E*) posterior abdominal uncini.

Remarks. Ten Hove (pers. com.) alerted the present author to the fact that the species frequently identified from the Indo-West Pacific as *P. stellatus* (Abildgaard, 1789) is actually *P. actinoceros* (Mörch, 1863). Reviewing published accounts *P. stellatus*, including that from the Indo-West Pacific, Pixell (1913: 78) states, under generic characters,: that the abdominal chaetae are "sickle-shaped (setae of *Salmacina*), and on p. 79: that she had "been able to find very few bladed sickles (setae of *Apomatus*) among the thoracic setae, the majority being rather short, still, simple bladed forms. The abdominal setae have the rounded teeth described by this author, but have nearly lost their sickle-like curve, this is, no doubt, due to their lengthened immersion in preservatives …".

According to Dew (1959: 42) the posterior thoracic chaetigers of *P. stellatus* bear "simple winged setae (Fig. 14D), sickle-shaped (*Salmacina*) setae, winged setae in majority; *Salmacina* setae usually lose their characteristic shape in preservative." Zibrowius (1970: 13) states, "Soies en faucille ("soies d'*Apomatus*") présentes dans les segments thoraciques postérieurs, comportant une partie distale dentelé relativement courte don't la longeur ne dépasse pas guère celles du limbe précedent." Pillai (1960), Straughan (1967: 238) and Fiege and Sun (1999: 133) apparently overlooked the presence of sickle-shaped chaetae in the posterior thoracic chaetigers. The abdominal chaetae are geniculate according to Zibrowius (1970), and Fiege & Sun (1999).

According to Fiege & Sun (1999: 133) a single species *P. stellatus* occurs in both the tropical western Atlantic and the Indo-West Pacific. In Australia: Shark Bay (Western Australia) (Augener, 1914); Thursday Island (Queensland) (Dew, 1959); Torres Strait, Pretty Beach, Cairns and Havannah Island (Queensland) (Straughan, 1967).

Many past publications expressed the belief that there is a single circumtropical species of *Pomatostegus*. However, according to ten Hove & Kupriyanova (2009: 78) there are three species. They consider *Pomatostegus macrosoma* Schmarda, 1861, a junior synonym of *Terebella stellata* Abildgaard, 1789, to be its type species. Ten Hove (pers.

com.) also alerted the present author to the fact that the Indo-West Pacific species is *P. actinoceros* Mörch, 1863, and not *P. stellatus* (Abildgaard, 1789).

Ten Hove & Kupriyanova (2009: 78) provide additional data with regard to opercular insertion, branchial eyes, and mouth palps. With regard to opercular insertion, however, they state that "from the fact that the first and second branchial radiole separated by the base of the peduncle, it is inferred that it is derived from the second normal radiole."

Subfamily Serpulinae Macleay, 1840, *sensu stricto* (emended)

Type genus *Serpula* Linnaeus, 1758

Type species *Serpula vermicularis* Linnaeus, 1758 (*vide* Heppel 1963)

Remarks. The subfamily name Serpulinae *sensu stricto* has been attributed to Macleay, 1840 by Pillai (1971), Lommerzheim (1979: 132), Jäger (1983: 33, 1993: 78) and Radwańska (1994: 41, 2004: 39); to Rioja, 1923 by Uchida (1978: 67) and Hartmann-Schröder (1996: 561).

Macleay's (1840: 387) Tribe *Serpulina* was based on the Upper Silurian fossil serpulid genus *Serpulites*. It is a name published before 1900, and it is derived from the stem of the generic name *Serpula* L. In terms of the rules of ICZN, authorship of the subfamily name Serpulinae is credited to Macleay (1840).

The subfamily diagnosis presented below takes into account the morphological characters of the extant genera constituting the *Serpula-Spiraserpula-Crucigera-Hydroides* clade (see Pillai & ten Hove, 1994).

Diagnosis. Operculum usually present: inserted in position of second branchial radiole; always chitinous; peduncle non-pinnulate, may be pinnulate in early juveniles of certain taxa. Depending on taxa, consists of a funnel-shaped structure bearing raii ending in radial lobes only, rarely simple and with few or no radii and radial lobes; or a proximal funnel-shaped structure with radii and radial lobes bearing a distal crown of spines (corona or verticil); or a funnel-shaped structure, bearing a number of blunt processes proximally below it. Inter-radiolar membranes absent; thoracic membranes present; apron, present in most taxa, absent in some as an adaptation to internal tube structures. Special collar chaetae frequently bayonet shaped, bearing a number of teeth on boss; may be reduced or modified in certain taxa. Thoracic uncini: saw-shaped in certain taxa, saw-shaped to rasp-shaped in others; most anterior uncinal tooth in thoracic and abdominal uncini larger than rest, simple. Distal ends of abdominal neurochaetae shaped like asymmetrically 'flattened trumpets', with one side longer than other, and bearing numerous serrations or denticulations. Tube not coiled; devoid of internal tube structures; or, coiled and bear internal tube structures.

Remarks. Diagnoses of the individual genera are presented in turn on the basis of their type species as they are dealt with. The Genus *Crucigera* Benedict, 1887, type species *Crucigera websteri* Benedict, 1887, which is not present in the Kimberleys collection but occurs in Australian waters, is distinguished from the other members of the *Serpula-Spiraserpula-Hydroides-Crucigera* clade by its possession of characteristic processes or swellings proximally below its *Serpula*-like funnel-shaped operculum. Differences in form, number and arrangement of those proximal processes, besides other characters, are employed to distinguish between its species.

Hitherto unused morphological characters

Two hitherto unused useful additional morphological characters are employed in this paper, since they were found to be useful in distinguishing between apparently similar species.

The first relates to the unserrated notch occurring between the boss and the blade in bayonet-shaped special collar chaetae. Comparisons of the unserrated notch between several species of Serpulinae were undertaken by the present author (unpublished), including 17 in the present paper. It was found that the length of the unserrated notch relative to the serrated part of the blade or length of the teeth on the boss, is reasonably constant for each species, and can be useful in their identification. This is especially so in newly formed special collar chaetae with their bosses and blades partly or wholly still within the collar fascicle, since older chaetae could be abraded to various extents with use. Six character states can presently be recognized with regard that character. The first two relate to the absence of an unserrated notch, either due to: (*a*) the entire blade being serrated, e.g., in *Serpula nudiradiata* n.sp. (Fig. 30A–E), or (*b*) the entire blade being unserrated, e.g., in *Spiraserpula caribensis* Pillai & ten Hove (1994: figs 14K–M, 15B–I). The remaining four concern the length of the unserrated notch relative to either the length of the teeth on the boss, or the length of the blade, as follows: (*c*) short, i.e. shorter than or equal to the length of the teeth on the boss, e.g., in *Spiraserpula snellii,* Pillai & ten Hove (1994) and Fig. 35E–G in the present paper; (*d*) moderately long, i.e., longer than main teeth on boss, but up to about a third the length of blade as in *Serpula* (?) sp. (Fig. 31D–H), *Spiraserpula zibrowii* Pillai & ten Hove (1994: fig. 12F–I) and *Spiraserpula plaiae* Pillai & ten Hove (1994: fig. 13N–T); (*e*) very long, i.e. longer than a third of the length of the blade (Fig. 17G–I) as in *Hydroides pseudexaltatus* n.sp.; (*f*) distally serrated, i.e., the entire blade beyond the boss, except for its distal end, is unserrated, a character state presently known to occur in only a single species, namely, *Serpula narconensis* Baird, 1864, (Fig. 22F in present account).

The second character relates to the gap separating the anterior abdominal tori of the two sides. In the present study it was observed that, during ontogeny, the anterior abdominal tori are initially short and located laterally in the earliest juveniles. As they grow older, additional uncini are added on at the medial end of each torus with the result that the tori gradually extend medially and become more dorsolateral in position. Depending on the species, as the worm grows older, the tori extend dorsally the corresponding pairs of the two sides may even almost meet or meet mid-dorsally. The uncinal tori of the more posterior abdominal segments however, do not increase in length as in the anterior segments, with the result that they gradually become more dorsolateral and lateral.

While abdominal uncinal tori occur laterally in the adults of certain species of *Hydroides*, more apomorphous conditions occur in others, as illustrated by the following examples. They are dorsolateral, separated by a wide gap in *Hydroides kimberleyensis* n.sp. (Fig. 14A); by a moderately wide gap in *H. spiculitubus* n.sp. (Fig. 20B); and by a very small gap in *Hydroides adamaformis* n.sp. (Fig. 11B). They almost meet along the mid-dorsal line in *H. minax* (Fig. 15B) and *H. exaltatus* (Fig. 12C).

Genus *Hydroides* Gunnerus, 1768

Type species. *Hydroides norvegica* Gunnerus, 1768.

Diagnosis. Operculum chitinous; inserted in position of second radiole; consists of a *Serpula*-like proximal funnel-shaped proximal part (or Latin equivalent infundibulum for brevity) usually bearing radii and radial lobes, surmounted by a distal crown (or Latin equivalent corona, or French verticil, for brevity) consisting of spine-like or other shaped processes. Number of thoracic chaetigers: seven. Special collar chaetae possess two to several teeth at base of blade and an unserrated notch of variable length relative to length of blade, depending on species. Most anterior uncinal tooth: larger than rest. Apron: present. Distal ends of abdominal neurochaetae shaped like asymmetrically "flattened trumpets", with one side longer than other, and bearing numerous serrations or denticulations. Tube: devoid of internal tube structures.

Remarks. The corona (or verticil) which consists of processes borne distally on the funnel-shaped operculum is an autapomorphous derivation of the condition in *Serpula*. Differences in its structure as well as of the marginal lobes of the proximal funnel-shaped part, besides other characters, are useful in distinguishing between species.

Tubes of many extant species *Hydroides* bear a pair of longitudinal ridges. The latter character could be useful in the determination of fossil *Hydroides* taxa, since the chitinous operculum is less likely to be found preserved.

With its numerous known species, and others still being discovered, *Hydroides* is currently one of, if not, the most successful among serpulid genera.

Hydroides adamaformis n.sp.

Fig. 11A–J

Type material. HOLOTYPE: AM W21457, south west corner of Lucas Island, Kimberleys, Western Australia, 15°13'S 124°31'E, 30 m, coll. by P.A. Hutchings, 24 Jul. 1988, st 101.

Description

Measurements. Maximum external width of tube, with flanges, 2.0 mm; total length of worm 20.0 mm, its thoracic width 1.0 mm; length of operculum and peduncle 4.7 mm, length of operculum alone 1.5 mm, length of radioles 2.7 mm, their pinnule-free tips about 0.6 mm, and length of abdomen 13.5 mm.

Tube. White, with two dorsolateral longitudinal ridges and a very wide flange on each side giving it a flattened trapezoidal cross-sectional appearance (Fig. 11A); longitudinal ridges separated by a wide, shallow, longitudinal groove between them; fine, incomplete, transverse grooves are present at irregular intervals between them; granular overlay absent.

Worm. Radioles colourless; scattered brownish specks present between thoracic segments; a small patch of brown pigment present anteroventral to each thoracic uncinal torus; a small patch of brown pigment present at dorsal and ventral ends of each uncinal torus in abdomen.

Operculum in holotype on the right side, rudimentary operculum on the left; corona heterospinous; consists of 6 swollen processes (Figs 11A–E), each shaped roughly diamond shaped, arising proximally from its bottom angle, widening medially towards its lateral angles and curved towards its distal angle where it ends as ablunt point at the centre of the crown; its two lateral angles project as two short spines. Each process possesses a thick, transparent cuticle. One coronal processes is larger than the rest, but like the rest, curved towards centre of crown. All lack medial and basal processes. Infundibulum cup-shaped rather than funnel-shaped, its marginal lobes ending in T-shaped to crescent-shaped tips (Figs 11A–E). Small whitish specks scattered throughout infundibulum. Radioles: 11 on left, 10 on the right; their pinnule-free tips as long as and slender as pinnules (Fig. 11A,B). Brownish clusters of prostomial ocelli present. Number of abdominal segments about 95, the last 10–12 bear capillaries.

Chaetae. Each collar fascicle bears 4 bayonet-shaped special collar chaetae. All, including one from deep within fascicle, possess two conical teeth each at base of blade (Fig. 11F–H); unserrated notch moderately long, about ¼ to ⅕ of total length of blade. Uncini: thoracic uncini saw-shaped (Fig. 11I) bear 6–7 teeth in a single row; anterior abdominal uncini similar (Fig. 11I) bear 4 or 5 teeth; posterior abdominal uncini rasp-shaped. Abdominal neuropodia bear about 5–6 chaetae per fascicle; their tips flattened and trumpet shaped; posterior abdominal segments bear capillaries while, a little anterior to them, capillaries present together with flattened trumpet shaped chaetae. Corresponding pairs of anterior abdominal uncini tori separated mid-dorsally by only a very small gap (Fig. 11B).

Remarks. *Hydroides adamaformis* superficially resembles is *H. tuberculatus* Imajima, 1960 (*vide* Imajima, 1960: 132, fig. 7a–j; and Fiege & Sun, 1999: 121, fig. 11A–C). As described and figured in both latter publications, infundibular lobes of *H. tuberculatus* end in simple pointed tips. On the other hand, those of *H. adamaformis* possess T-shaped to crescentic tips (Fig. 11A–E). The number of coronal processes in *H. tuberculatus* is 5; their shape is sub-triangular, and their cuticle is thick as described by Fiege & Sun (1999: 123). All the coronal processes in *H. adamaformis*, including the modified one, are diamond-shaped, and each bears a pointed spine on each lateral angle, while its distal angle is blunt and curved toward centre of the crown (Fig. 11A–E). On the other hand, all coronal spines in *H. tuberculatus* lack the pair of laterally directed spines occurring in *H. adamaformis*, whilst its modified coronal spine ends in a ventrally directed beak-like curved process (Fiege & Sun, 1999: fig. 11A). Although the number of coronal spines in *H. adamaformis* appears to be 5 from certain angles (Fig. 11B,C), it is actually 6 (Fig. 11D).

The external swelling described in Imajima's original account of *H. tuberculatus* (1976: 133, fig. 7a–c) is different: "each spine of the crown has a small external swelling at its shoulder, and a somewhat pointed accessory basal radial spine." As seen in Fiege & Sun's specimens of *S. tuberculatus*

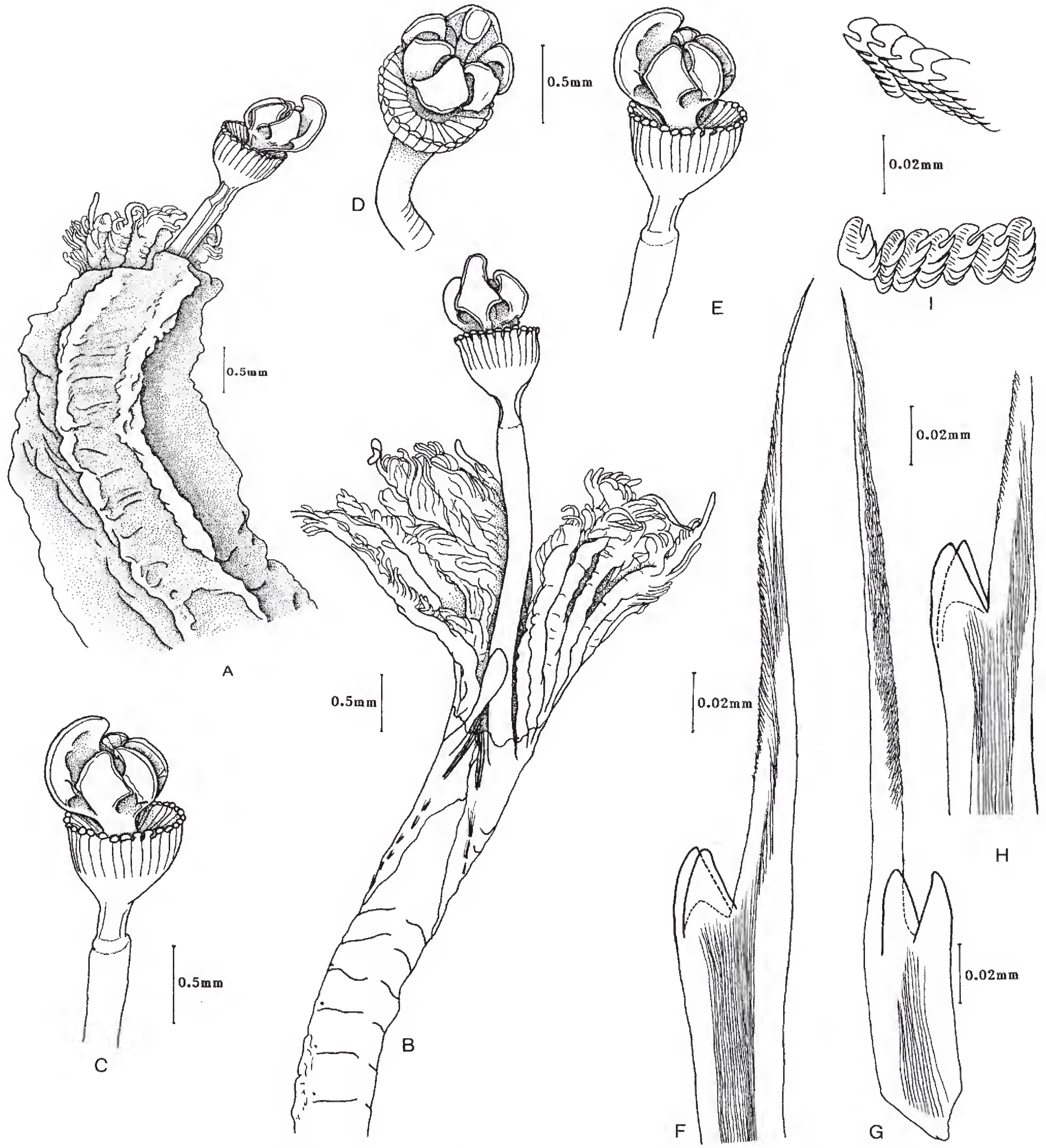

Figure 11. A–I, *Hydroides adamaformis* n.sp., from holotype AM 202931. (*A*) tube, with worm *in situ*; (*B*) anterior end of worm, showing operculum, rudimentary operculum and arrangement of anterior abdominal uncinal tori; (*C–E*) different views of operculum; (*F–H*) bayonet-shaped collar chaetae (G, from within collar fascicle); (*I*) uncini: upper figure, thoracic uncini; lower figure, anterior abdominal uncini.

from the South China Sea (Fiege & Sun, 1999: fig. 11B) the distal ends of their sub-triangular unmodified coronal spines are quite stubby, somewhat inwardly distended, and bears an external anteriorly directed, transverse ridge-like swelling. The latter is the external swelling described by Imajima (1976) and as "a small chitinous knob on the external side of tip (fig. 11A)" by Fiege & Sun (1999: 123). *Hydroides adamaformis* lacks such an external terminal chitinous knob on its coronal spines (Fig. 11A–D).

Hydroides trilobulus Chen & Wu, 1978 also has a remote resemblance to *H. adamaformis*. However, its corona consists of only three swollen processes, and their shoulders do not end in lateral spines, and its infundibular radii end in simple processes, whereas those of *H. adamaformis* end in swollen T-shaped to crescentic tips.

Etymology. The specific name *adamaformis* is derived from the Latin *adamas* = diamond, and refers to the diamond-shaped external appearance of the coronal processes, although their distal ends are curved inwards.

Hydroides exaltatus (Marenzeller, 1885)

Figs 12A–F, 13A–L

Eupomatus exaltatus Marenzeller, 1885: 217, fig. IV a.
Eupomatus exaltatus.—Willey (1905: 312, pl. VII, fig. 182)
Hydroides exaltata.—Pillai (1960: 10, fig. 4A–E), Imajima (1976: 127, fig. 4A–J), Imajima, (1977: 94), Imajima (1979: 168), Imajima & ten Hove (1984: 48), Imajima & Hove (1986: 4), Fiege & Sun (1999: 186, fig. 5D–F).

Material examined. Kimberleys, Western Australia: 1 specimen, AM W202941, south side of Slate Island, 15°32'S 124°24'E, lower intertidal, rocks, 9 Jul. 1988, st 5; 7 specimens, AM W21456, south west corner of Lucas Island, 15°13'S 124°31'E, 30 m, 24 Jul. 1988, st 101. 1 incomplete specimen with tube, AM W202931, east side of Fenelon Island, 14°07'S 125°43'E, 6 m, 18 Jul. 1988, st 64; 1specimen without tube, incomplete posteriorly, AM W202945, south west corner of Lucas Island, 15°13'S 124°31'E, 30 m, 24 Jul. 1988, st 101. 1 incomplete specimen without tube, AM W21413, sand cay on Port George IV, 15°205'S 124°39'E, 12 Jul. 1988, st 26; all coll. by P.A. Hutchings.

BMNH 1959.12.16.19, determined by Pillai (1960) as *H. exaltata* (Marenzeller), from the Pearl Banks, Sri Lanka.

Description

Measurements. A maximum external diameter of 1.6 mm occurs in specimen from AM W202941. Longest available specimen has a total length of 16.8 mm and thoracic width of 1.0 mm; length of operculum and peduncle 4.2 mm, operculum alone, 2.0 mm; abdomen10.4 mm. Smallest specimen is a juvenile only 3.8 mm long with a thoracic width of 0.5 mm.

Tube. White, quadrilateral cross-sectional appearance and lacks a granular overlay (Fig. 12A,B,D); a pair of dorsolateral longitudinal ridges present, discontinuous in places; a thinner, more discontinuous, less developed median longitudinal ridge may or may not be present; transverse ridges present.

Worm. A brown transverse pigment band present anterior to each thoracic uncinal torus. Coronal and infundibular spines end in transparent light-brown tips. A juvenile specimen in collection has two opercula (Fig. 13L). Corona heterospinous; total number of coronal spines 6 to 10 in available specimens; in older specimens most dorsal spine enlarged, sub-terminally expanded laterally before ending in a ventrally curved hook (Figs 12E,F, 13A,B), narrower in younger specimens (Fig. 12C). A dimple may be present externally, on the sub-terminal enlargement (Fig. 12E,F). Remaining coronal spines curved outwards and tapered to a point. A short medial spine occurs halfway along each coronal spine, including the enlarged one (Figs 12F, 13A,B); may not be developed in juveniles. Infundibular radii end in simple pointed spine-like processes; number 22 in four juveniles. Infundibular radii end in simple pointed spine-like processes; number 22 in four out of the seven specimens, 23 in two, and only 14 in one of the two opercula of the juvenile described above. Each infundibular spine appears jointed to the marginal lobe from which it arises, curved outwards, and tapers to a simple pointed tip in older specimens (Figs 12E,F, 13A,B); less obvious in juveniles. Radioles range from 7 per side in juvenile described above, to 14 on left and 13 on right in an older specimen; their pinnule-free tips very short, as slender as or thinner than pinnules. A pair of prostomial ocellar clusters present, purplish brown in colour, lighter in juveniles.

Chaetae. Special collar chaetae bayonet-shaped (Fig. 13C–I), total number of teeth at base of blade 2–6; of which 2 may be large and the rest one to few smaller accessory teeth (up to 4 observed) at base of blade; two large worn out teeth seen in an older chaeta (Fig. 13C). A newly formed bayonet-shaped chaeta from within fascicle has 3 main teeth and a slightly smaller fourth one (Fig. 13E); another, 1 main tooth and 4 smaller teeth (Fig. 13I). Unserrated notch in newly formed chaetae: moderately long, about one sixth of total length of blade (Fig. 13E); may be indistinct (Fig. 13I); blade long and tapered. Thoracic uncini saw-shaped: bear 7 teeth (Fig. 13J); anterior abdominal uncini similar, with 5 teeth in single row (Fig. 13K); posterior abdominal uncini rasp-shaped.

Remarks. The tube of *Hydroides exaltatus* (Marenzeller, 1885) according to Imajima's figure and description (1976: 128, fig. 4J), is "white, thick; it is subtrapezoidal in cross-section with three low longitudinal ridges and many growth rings (fig. j)." Fiege & Sun (1999: 116) give a similar description. Marenzeller's (1885: 217) type material of *Hydroides exaltatus* came from Eno-shima, Japan, but his original species description does not mention the short medial spine on each coronal spine. Willey (1905: 312, plate VII, fig. 182) and Pillai (1960: 110, fig. 4A–E) describe the coronal spines as being plain and devoid of accessory spines. Fiege & Sun (1999: 116, fig. 5D–F) also do not describe the presence of an accessory spine on each coronal spine, but the operculum is similar to that described by Willey (1905) and Pillai (1960).

However, according to Imajima's description (1976: 127, fig. 4a–j), which does not include material from Eno-shima, each coronal spine, including the enlarged one, has a short medial spine close to its base. The Kimberleys specimens (Figs 12F, 13A,B) agree with Imajima's (1976) description. It appears, therefore, that there are two apparently similar species. The infundibular processes in both are simple, and the coronal spines are similar in that the enlarged pointed main spine is curved towards the centre of the crown, while the remaining ones are shorter, end in simple tapered tips, and are curved outwards.

Other collections identified as *H. exaltatus* were examined with a view to seeking an explanation for the above differences. A specimen, BMNH 1992.382, collected by Pillai in 1971 from Biak, West Irian, Indonesia, determined as *H. exaltatus* (Marenz) by ten Hove in 1988, is also similar to the older specimens from the Kimberleys with regard to this character. BMNH 1959.10.19.3-4, from Bougainville, Solomon Islands identified as *H. exaltatus* according to the label, contains 2 detached opercula and a detached corona. In the specimens from West Irian and Bougainville the enlarged coronal spine lacks the medial spine, while the unmodified coronal spines bear a short medial spine each.

Pillai's specimen from Sri Lanka, BMNH 1959.12.16.19, its identity confirmed by ten Hove in 1969, was re-examined during this study. Its enlarged coronal spine does not possess a medial spine, as in the above specimens from Bougainville. However, careful re-examination revealed that, of the remaining 7 coronal spines, the one next to the enlarged one lacks the short medial spine, another possesses only an insignificant stub, and each of the rest possesses a short medial spine. They are quite transparent and located close to the base of enlarged spine. Moreover, the adjacent medial

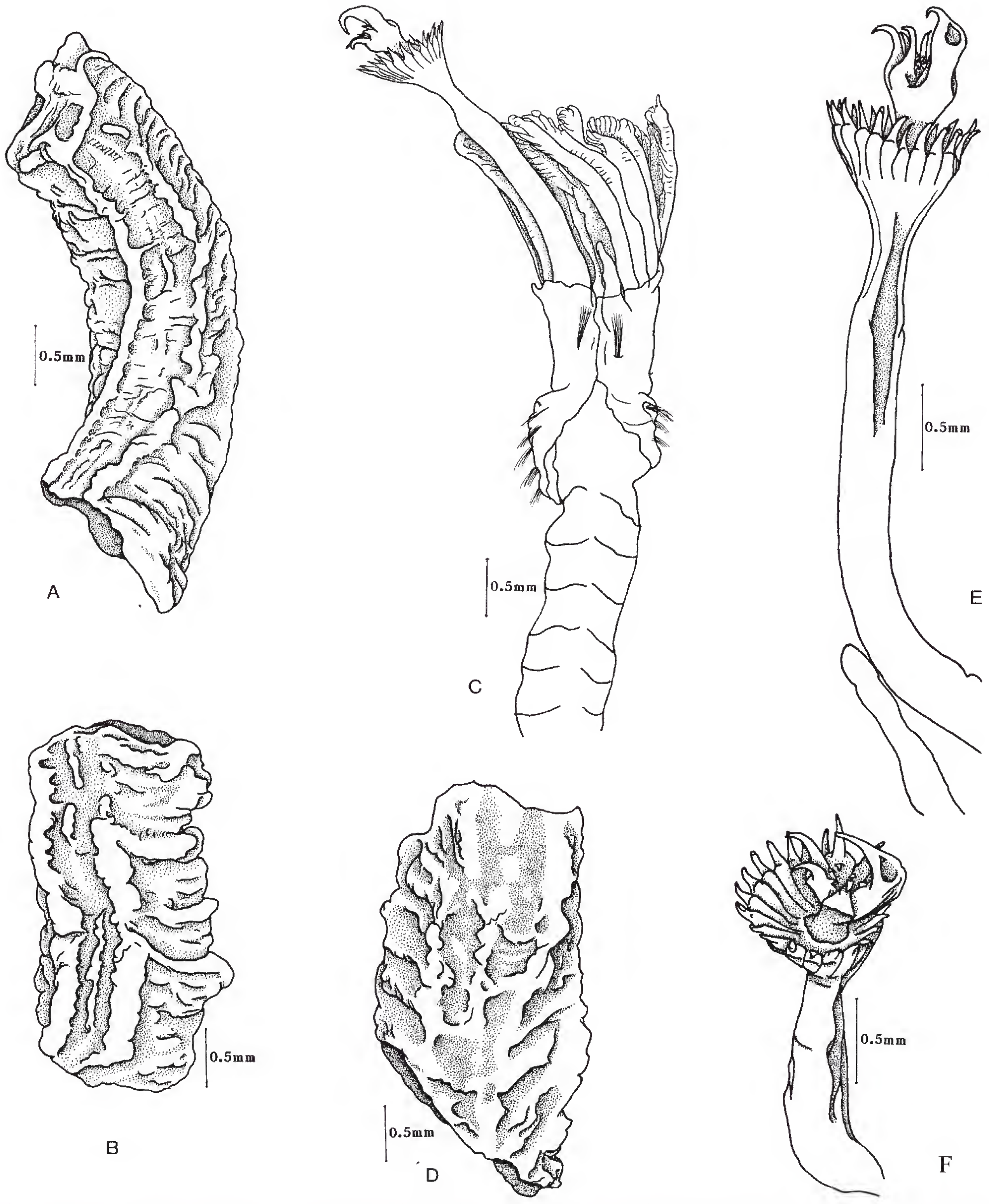

Figure 12. A–F, *Hydroides exaltatus* (Marenzeller, 1885). A–C from a specimen separated from AM W202941: (*A,B*) two tube fragments; (*C*) anterior part of worm showing operculum, radioles and arrangement of anterior abdominal tori. D–F: from a specimen in AM W202964; (*D*) tube fragment; (*E,F*) two views of operculum; (*E*) also shows rudimentary operculum.

spines meet and appear like demarcating lines between the bases of the main spines. It is evident, therefore, that the short medial spine on the coronal spines is a variable character in *H. exaltatus*. It may not be developed in some, or even in all the coronal spines; they may also vary in position, being closer to the base in some individuals than in others.

Another variation observed concerns bayonet collar chaetae. Although Imajima (1976) states that collar chaetae may bear one or two conical teeth at the base of the blade, they bear more than 2 in the Kimberleys material (up to 6 were counted), composed of 1 or 2 main teeth and the rest of smaller accessory teeth (Fig. 13D–I).

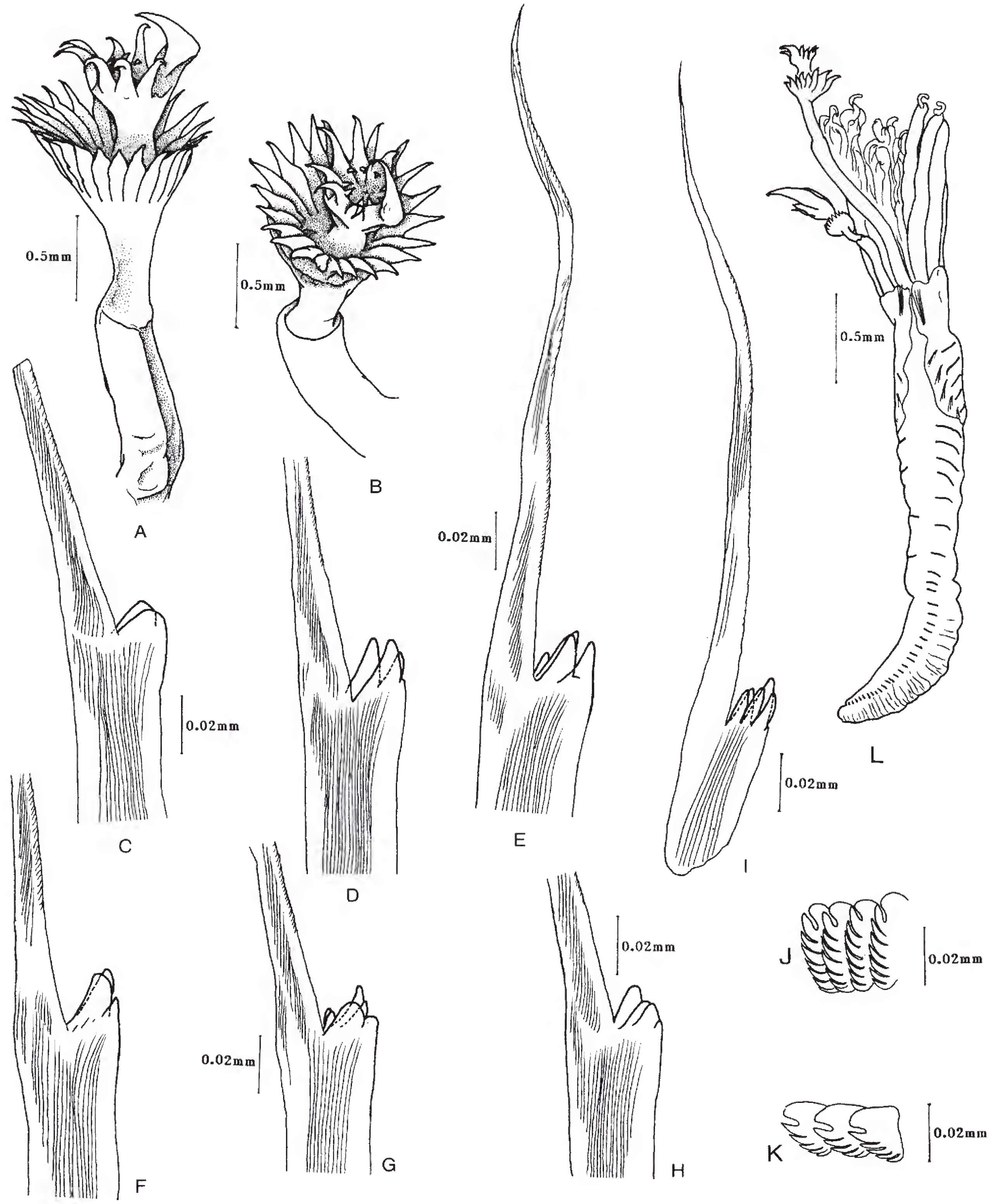

Figure 13. A–L, *Hydroides exaltatus* (Marenzeller, 1885), from AM W21496. (*A,B*) two views of an operculum; (*C–I*) bayonet collar chaetae C, an older chaeta with worn out teeth. Remaining bayonet chaetae have 3 to 5 teeth at base of blade. Note that teeth do not extend way down the boss as in *H. pseudexaltatus* (Fig. 17E,F,G–I), and their un-serrated notch is moderately long compared to that in *H. pseudexaltatus* in which it is very long.]; (*J*) thoracic uncini; (*K*) anterior abdominal uncini; (*L*) a juvenile specimen; it has two opercula; the main spine in the better-developed operculum is directed inwards, while it is directed outwards in the other; its anterior abdominal uncinal tori are lateral, separated by a wide gap dorsally, compared to older specimens (Fig. 12C) in which they almost meet mid-dorsally.

Hydroides kimberleyensis n.sp.

Figs 14A–Q

Type material. Kimberleys, Western Australia, HOLOTYPE: AM W21391, east side of Fenelon Island, 14°07'S 125°43'E, 6 m, 18 Jul. 1988, st 64. PARATYPE, AM W202963, reef north-west of Buffon Island, 14°55'S 124°48'E, 20 m, 23 Jul. 1988, st 85; both coll. by P.A. Hutchings.

Description

Measurements. Apparently a very small species; maximum external tube diameter: 1.2 mm in holotype, 1.0 mm in paratype. Total length of longer of the two worms is 10.0 mm, the other 9.1 mm. However, latter sexually mature, since ova being present in posterior part of abdomen. Thoracic width: only 0.5 mm in both. Length of operculum and peduncle 2.5 mm in first specimen, 1.7 mm in the second; length of abdomen, 5.1 mm long in first specimen, 7.3 mm in second. Number of abdominal segments: 66 in first, 71 in second; capillaries starting from 63rd segment in both.

Tube. Light caramel coloured in holotype, white in paratype; lined internally by chitin-like material, light brown in the former, more conspicuous and darker brown in the latter. It has a characteristically wide, apparently flattened dorsal area with a longitudinal ridge on each side, sloping sides, and a flange on each side, giving it a trapezoidal cross-sectional appearance (Fig. 14Q). Fine transverse ridges traverse the gap between the two longitudinal ridges, most of them not extending beyond the wide mid-dorsal longitudinal groove itself, thus leaving the longitudinal ridges comparatively clear. Irregular transverse ridges present along the flanks; a granular overlay absent.

Worm. Posterior part of collar and ventral side of thorax brown; a transverse brown band present anterior to each thoracic uncinal torus; brownish pigmentation present transversely across ventral side of abdominal segments, fainter bands dorsally in posterior part of abdomen, latter more pronounced in second specimen. Infundibular lobes are brown distally, their tips blackish; opercular peduncle whitish.

Operculum on the right side in both specimens; number of radioles radioles 8 per side, their pinnule-free tips as long as and as thick as pinnules (Fig. 14A,L,Q). Corona of both specimens has 5 triangular, brownish, chitinous processes each, which arise directly from the infundibulum, i.e., not collectively borne on neck-like part arising from it (Fig. 14A–D,L–P,Q); their blunt tips directed outwards. Diameter of coronal base somewhat greater than or equal to that of infundibulum, so that, when viewed from anterior end, only the pointed tips of the marginal infundibular processes may be seen, if at all (Fig. 14D,N). Coronal processes (Fig. 14A–D,L–P,Q) translucent light brown, their tips and edges transparent light brown to honey coloured; each roughly triangular in cross-section, thick and ending distally in a bluntly pointed transparent tip; also possesses, medially, at it base, 4–5 tiny processes (Fig. 14D). Coronal processes are all similar in holotype (Fig. 14B,C); in the paratype, the translucent part at the tip of one of the coronal spines bears a short, sharp, translucent, medial sub-terminal spine (Fig. 14O,P), which appears to represent the fully developed condition.

Infundibular lobes minute, acutely triangular, and end in outwardly curved pointed tips (Fig. 14A–C,L–P,Q). They number 24 in the holotype, difficult to count in the paratype. Two faintly brown clusters, of what appear to be prostomial ocelli, present in the first specimen, darker and clearer in the second. Thoracic glands: not discernible. Anal segment appears to bear a pair of ocellar clusters; they are clearer in the second.

Chaetae. Each collar fascicle bears about 5 bayonet-shaped special collar chaetae. Two newly formed ones from within the fascicle possess a small accessory tooth between two larger conical teeth (Fig. 14E,F); remaining three older, their blades and accessory tooth and conical teeth at the base of blade worn out (Fig. 14G–I). In newly formed bayonet chaetae, the unserrated notch is comparatively short, about one-tenth to about one-twelfth of the total length of the blade (Fig. 14E,F). Thoracic uncini (Fig. 14J) and anterior abdominal uncini (Fig. 14K): saw-shaped, bear 6 and 5 teeth, respectively; posterior abdominal uncini rasp-shaped. Abdominal uncinal tori: 15 or so pairs of anterior abdominal tori are dorsolateral, with a wide gap separating the tori of the two sides (Fig. 14A).

Remarks. *Hydroides kimberleyensis* is somewhat similar with regard to its small size and characters of its coronal processes to *H. xishaensis* Chen & Wu, 1978, *H. trilobulus* Chen & Wu, 1978, and *H. rhombobulus* Chen & Wu, 1980, but there are important differences among them. Total lengths of their holotypes are, only 4.8 mm for *H. xishaensis* and 4.0 mm for *H. trilobulus*, while it is 9.0 mm for *H. rhombobulus* Chen & Wu, (1980: 250). Total lengths of the two specimens of *H. kimberleyensis* are 10.0 mm and 9.1 mm, respectively. In spite of their comparatively minute sizes, the holotype of *H. xishaensis* has a total of 20–24 branchial radioles (10–12 per side), while that of *H. trilobulus* has a total of 20–26 (i.e., 10–13 per side). On the other hand, the holotype of *H. kimberleyensis* has only 16 radioles (8 per side). The 9.0 mm holotype of *H. rhombobulus* has 12 radioles (6 per side), somewhat similar to *H. kimberleyensis* in this respect.

The number of coronal processes in both specimens of *H. kimberleyensis* is 5, but it is 4 in *H. rhombobulus*. Moreover, the colour and form of coronal processes in *H. kimberleyensis* and *H. rhombobulus* are different. In *H. kimberleyensis* they are brownish, triangular, convex on the outside, with transparent edges and tips, and each bears 4–5 tiny basal processes (Fig. 14D). In *H. rhombobulus*, on the hand, the coronal spines are rhomboidal in shape and apparently lack medial basal processes. In *H. kimberleyensis*, the diameter of the infundibulum and infundibular processes is nearly equal to that of the corona, the infundibular lobes slender, and their pointed tips pressed closely against the coronal base (Fig. 14A–D,L–Q,). In *H. rhombobulus*, on the other hand, the diameter of the infundibulum and infundibular processes is greater than that of the corona, and its infundibular lobes are directed outwards (Chen & Wu, 1980: pl. 1, fig. 1). Minor differences also appear to exist in their chaetae. Bayonet shaped collar chaetae of *H. kimberleyensis* typically possess two conical processes at the base of the blade, with a smaller accessory tooth between them, but in *H. rhombobulus* they have been described and figured as possessing only two conical processes. Thoracic and abdominal uncini of *H. kimberleyensis* bear 6 and 5 teeth, respectively, whereas they bear 7 and 6, respectively, in *H. rhombobulus*.

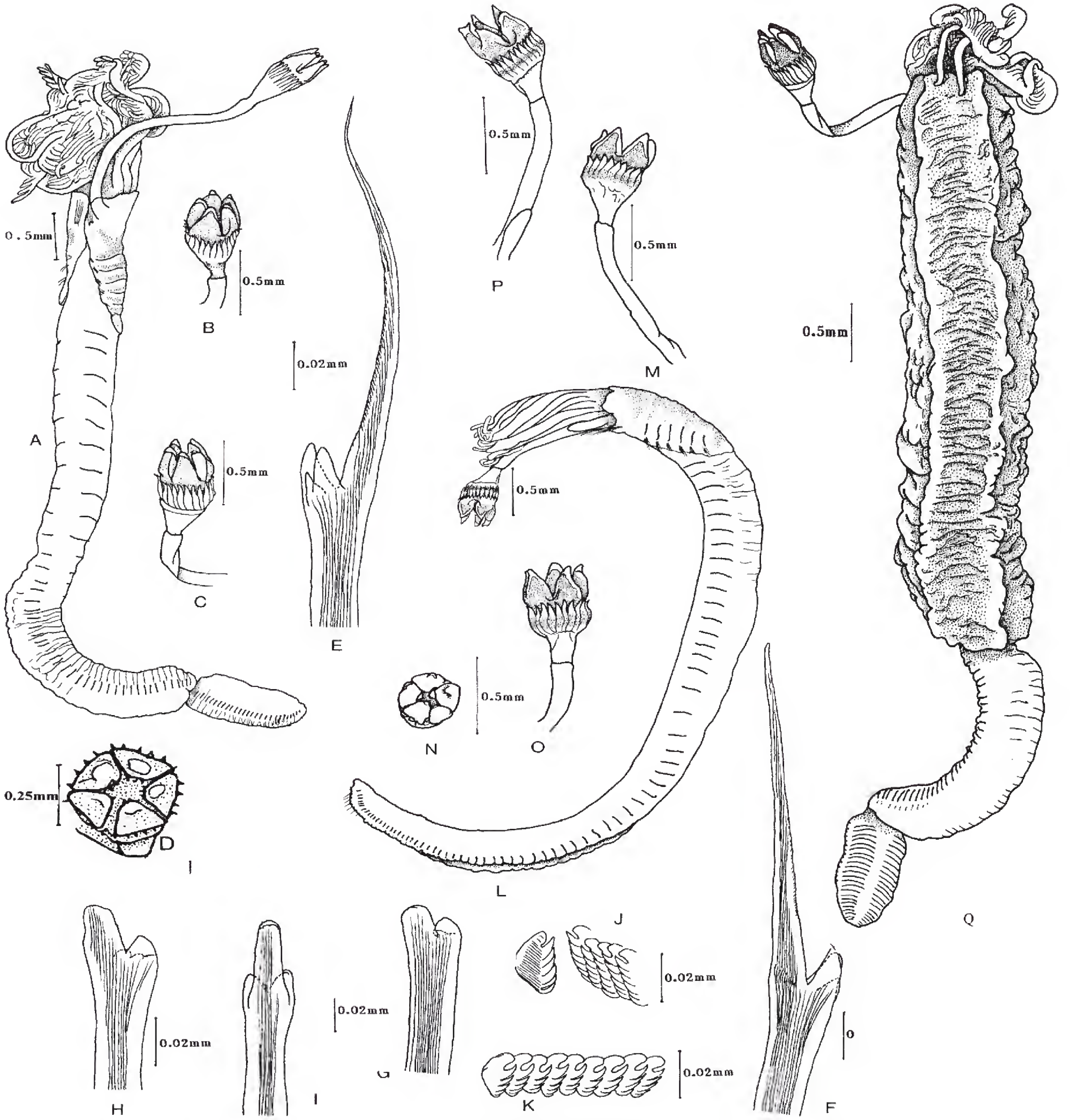

Figure 14. A–K and Q, *Hydroides kimberleyensis* n.sp., from holotype AM W202931: (*A*) whole worm removed from its tube; (*B–D*) different views of operculum; (*E–I*) bayonet-shaped special collar chaetae. J–K, uncini: (*J*) thoracic uncini, (*K*) anterior abdominal uncini. L–P, from paratype AM W202963: (*L*) whole worm; (*N–P*) different views of operculum. (*Q*) tube with worm *in situ*.

Hydroides xishaensis Chen & Wu, 1978 (plate 1, fig. 1) has 5 triangular, concave coronal processes, lacking basal spines, and their pointed tips are directed towards the centre of the corona like claws of a grapple-iron. As also shown in Chen & Wu's figure the infundibular processes and their triangular tips are directed outwards. In contrast, the coronal processes of *H. kimberleyensis* are not clawed and directed inwards but outwards at their tips, and each one of them bears a number of basal spines (Fig. 45D). Moreover, its infundibular processes are pressed against the bases of its coronal spines, and only their tips are curved outwards. An additional character to support the distinction between the two species concerns differences in the unserrated notch in the bayonet-shaped special collar chaetae. As figured by Chen & Mu (1978: plate 1, figs 2,3), it is absent or short. On the other hand, it is moderately long (longer than the teeth on the boss, but up to one about ⅓ the total length of the blade) in *H. kimberleyensis*.

Unlike in many species of *Hydroides* dealt with in this paper, anterior abdominal tori are lateral, with a wide mid-dorsal gap separating them.

Etymology. Named after the type locality, the Kimberleys, Western Australia.

Hydroides minax (Grube, 1878)

Figs 15A–G, 16A–F

Serpula minax Grube, 1878: 269, table XV, fig. 5.
Hydroides minax.—Pillai (1969: 8, fig. 3A–E), Imajima (1976: 129, fig. 5), Imajima (1982:42), Imajima & ten Hove (1984: 48), Imajima & ten Hove (1986: 3).
Hydroides monoceros.—Straughan (1967: 221, fig. 6n), Pillai (1971: 110, fig. 7D).

Material examined. Kimberleys, Western Australia; 1 specimen, AM W21445, reef north-west of Buffon Island, 14°55'S 124°41'E, 20 m, 23 Jul. 1988, st 85; 1 specimen AM W20295, south side of Long Reef, 14°01'S 125°44'E, 20 m, 18 Jul. 1988, st 60; 1 specimen, AM W202936, Bernouli Island, 12 Jul. 1988, st 30; all coll. by P.A. Hutchings.

Additional material examined. BMNH 1924.6.13.132, from the Pearl Banks, Sri Lanka, identified by Pillai (1960) as *Hydroides minax*; BMNH 1961.8.156, from Zanzibar, determined by C. Crossland as *H. monoceros*; BMNH 1970.828, a specimen identified as *H. monoceros* by J.H. Day. BMNH 1992.320, a juvenile specimen from Matio Is., coll. by P. Gibbs during the Royal Society 1965 Expedition to the Solomon Islands and determined by H. Zibrowius as *H. minax*. BMNH 1937.6.6.10, specimens from Doom Islands, Sorong, West Irian, Indonesia, coll. by Pillai in 1970, determined by ten Hove as *H. minax*. BMNH, a collection from Akaba, Red Sea, by K. Reich in 1936; determined by ten Hove as *H. minax*.

Description

Measurements. From a complete specimen in Kimberleys collection AM W21445: maximum width of tube of 4.7 mm; total length of worm 24.0 mm, its thorax 2.0 mm wide; length of operculum and peduncle 8.0 mm, operculum alone 4.6 mm. Operculum occurs on right side, rudimentary operculum on left; 21 radioles on left side, 18 on right. Length of abdomen: 13.3 mm, 122 abdominal segments, with capillaries starting from segment 111. Although specimen from AM W202951 is incomplete posteriorly, it has two well-developed opercula; thorax 1.2 mm wide; lengths of two opercula and peduncles, 4.0 mm & 3.5 mm; lengths of opercula only, 1.7 mm & 1.9 mm; numbers of coronal spines: main spine + 5, and main spine + 6; lengths of main spines 0.7 mm & 1.0 mm; numbers of infundibular lobes, 18 & 20; numbers of radioles, 11 + operculum, and 12 + operculum.

Tube. White; partially covered over by coral. Although surface is irregular due to presence of irregularly shaped transverse ridges, two longitudinal ridges can be recognized anteriorly, which gives it a trapezoidal cross-sectional appearance. That of specimen in AM W21445 has 2 irregularly developed dorsolateral longitudinal ridges anteriorly (Fig. 15A), smooth transverse growth markings, a dark-brown pigment overlay in places, and about three thickened transverse ridges or peristomes anteriorly, not as well developed as in certain other species of *Serpula*.

Worm. Operculum blackish in larger specimen AM W21445, translucent white with faintly yellowish spines in the second. Number of coronal processes 7 in former (Fig. 15D), and 6 and 7 in the two opercula of second, AM W202951 (Fig. 16C); all devoid of basal processes. Most dorsal coronal process stout, elongated, and terminates in three strong sharply pointed hooks, one curved ventromedially and the other two curved posterolaterally (Figs 15B–E, 16C); rest simple, outwardly curved spines. First specimen has the higher number of infundibular lobes, 24. They are simple and end distally in a swelling (Figs 15B–E, 16C) which may be somewhat T-shaped (Figs 15B, 16C). Maximum number of radioles per side in the two specimens is 21; their pinnule-free tips short, slender; only slightly thicker than the pinnules. A blackish cluster prostomial ocelli present on each side, anterior to the second thoracic chaetiger (Fig. 15B,C). Abdomen deeply folded along mid-ventral line and its cuticle appears to be transversely sloughed off as spicules (Fig. 15C).

Chaetae. Special collar chaetae bayonet-shaped (Figs 15F,G, 16D–F), bear 2 conical processes at base of blade. Thoracic uncini saw-shaped, with 7 teeth in single row (Fig. 16A); anterior abdominal uncini similar, with 4 or 5 teeth (Fig. 16B); posterior abdominal uncini rasp shaped. Anterior abdominal uncinal tori are long, and corresponding pairs almost meet or meet along mid-dorsal line (Fig. 15B). Anterior abdominal segments bear about 13 chaetae with flattened trumped shaped ends.

Remarks. Pixell (1913), Fauvel (1953) and Straughan (1967a,b) distinguish between *H. minax* (Grube, 1878) and *H. monoceros* Gravier, 1908, on the basis that the corona of the latter arises asymmetrically from the infundibulum in the former but symmetrically in the latter. Pillai (1971) mentioned the difficulty of distinguishing between them, and the need for further studies to specify the differences. Hartman (1959) believed that they may be synonymous. Imajima (1976, 1982) and Imajima & ten Hove (1984, 1986) considered them synonymous, as also supported in the present study. Variations in their coronal spines range from those occurring in juvenile specimens of *H. minax* to those in older specimens of *H. monoceros*. They are translucent, somewhat greenish-yellow in colour, and the most dorsal coronal spine is very short in juveniles, whereas in older specimens they are brownish and the most dorsal spine is comparatively very long. The specimen with the longest modified coronal spine examined in the study is in Crossland's collection from Zanzibar. Some of its measurements are as follows: maximum tube diameter 3.1 mm; length of operculum and peduncle 6.0 mm; length of operculum including long stiff constriction below the infundibulum and the peduncle 4.2 mm, and length of most dorsal spine 3.0 mm. The tips of infundibular spines may be more or less swollen, irrespective of the age and size of the worm. Sloughing off spicules of ventrally along the abdomen does not appear to occur to the same extent as in *Hydroides spiculitubus* n.sp., described below.

Hydroides pseudexaltatus n.sp.

Fig. 17A–K

Material examined. Kimberleys, Western Australia: HOLOTYPE: AM W202930, island off North East Heywood Island, 15°05'S 124°25'E, rocks & mud, low tide, coll. P.A. Hutchings, 10 Jul. 1988, st 11.

Description

Measurements. Total length of worm 14.2 mm; width of thorax 1.1 mm; length of operculum and peduncle 3.6 mm; of operculum only 1.6 mm; its diameter 1.0 mm. Length of abdomen 8.1 mm; number of segments 101; capillaries commence from segment 86.

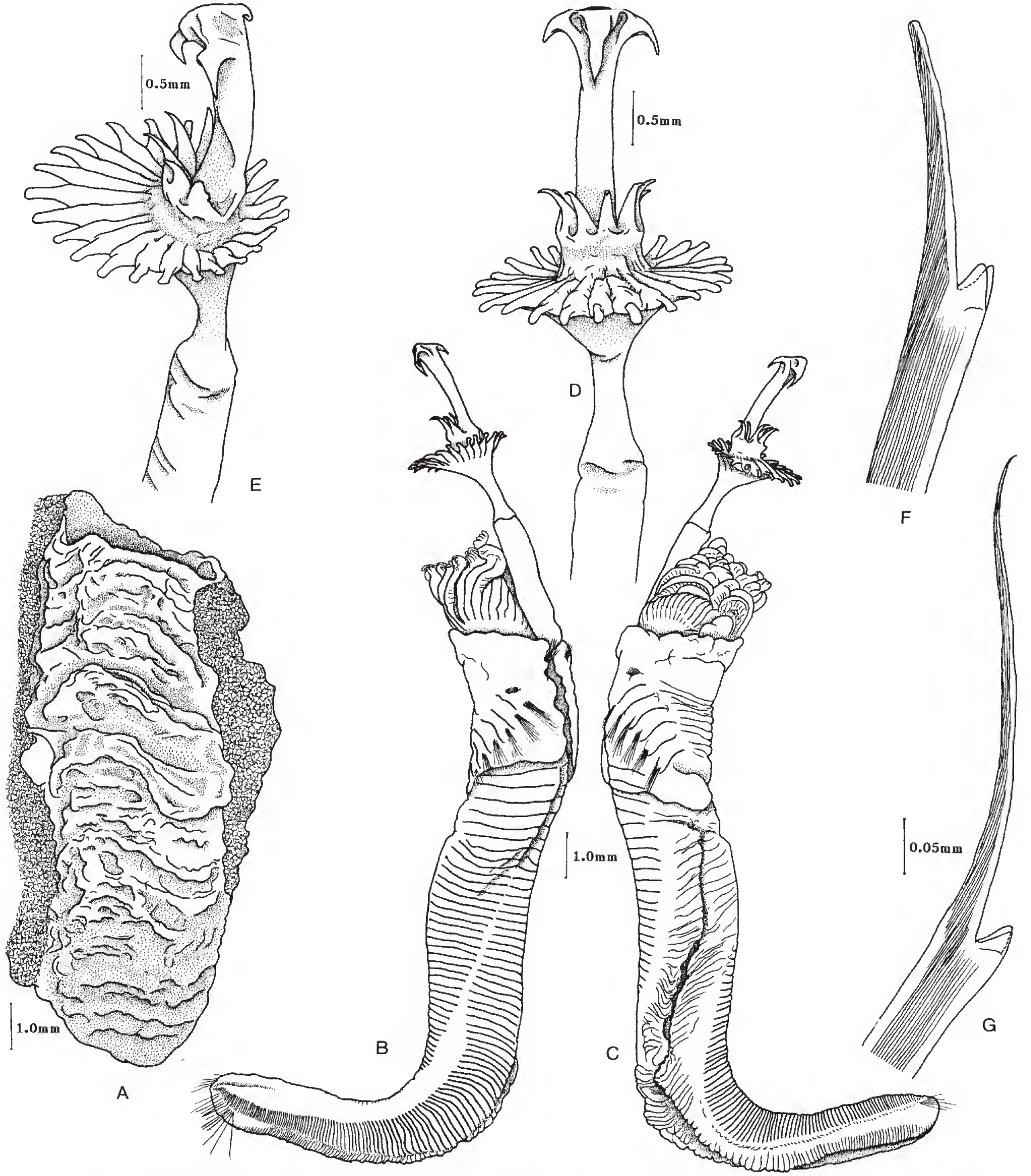

Figure 15. A–G, *Hydroides minax* (Grube, 1878), from AM W202951: (*A*) part of tube on substratum; (*B,C*) two different views of worm; A shows arrangement of anterior abdominal tori of the two sides which meet or almost meet dorsally; (*D,E*) two enlarged views of operculum; (*F,G*) two bayonet-shaped special collar chaetae.

Tube. White, maximum external diameter at its anterior end 2.7 mm; its surface is irregular, but two somewhat rounded and irregular longitudinal ridges with a moderately wide shallow longitudinal gap between them can be recognized, and an irregular flange on either side (Fig. 17A) which gives it a roughly trapezoidal cross-sectional appearance. Irregular transverse ridges present, also between the longitudinal ridges. Fractured end of tube reveals a moderately thick caramel to light brownish translucent inner layer, with patchy brownish pigment inside.

Worm. Coronal and infundibular processes transparent light yellow and with brownish tips. Corona heterospinous and consists of 9 spines, all devoid of medial, lateral and basal processes (Fig. 17D); enlarged dorsal spine somewhat swollen in middle and ends distally in a hook curved towards

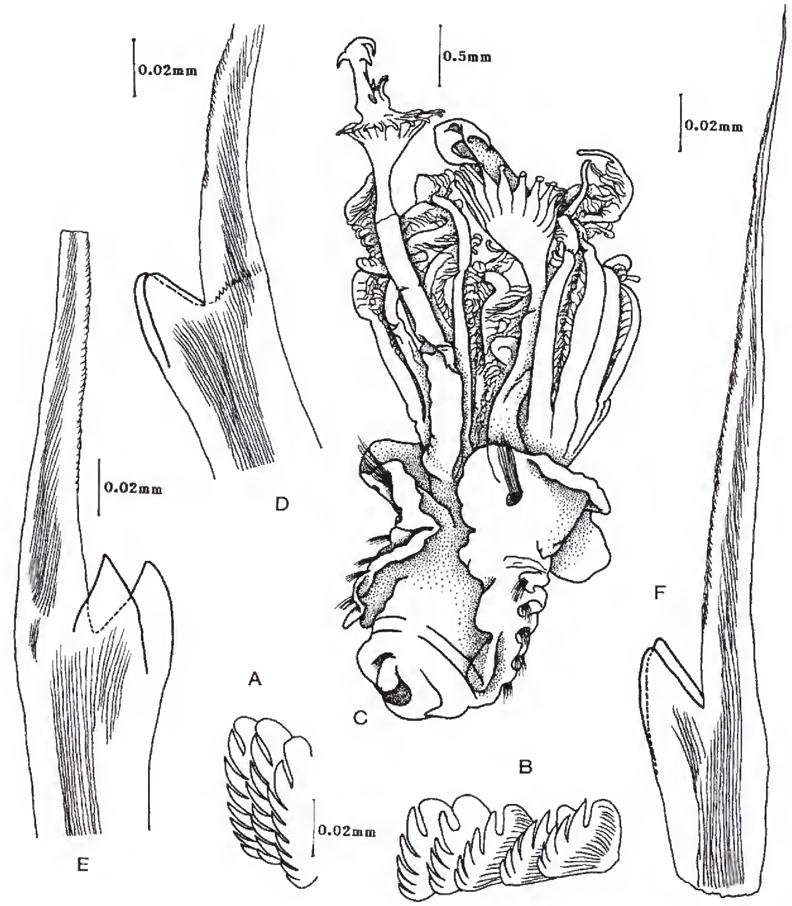

Figure 16. A–F, *Hydroides minax* (Grube, 1878), from AM W202951. A,B from specimen in Fig. 15I,J: (*A*) thoracic uncini; (*B*) anterior abdominal uncini; (*C*) anterior end of another worm from the same collection having two opercula; (*D–F*) bayonet-shaped special collar chaetae.

centre of crown (Fig. 17B–D); remaining coronal spines much shorter and end in simple outwardly curved pointed tips. Infundibular processes number 21; ending distally in swollen to somewhat T-shaped tips (Fig. 17B–D). Brownish clusters of prostomial ocelli present.

Chaetae. Special collar chaetae bayonet-shaped and possess two elongated conical teeth at the base of the blade (Fig. 17E–I), originating way down along the boss.further down along the boss than in other species of *Hydroides*, as shown by dotted lines in Fig. 17E,F, and Fig. 17G–I. As also shown in latter figures, the unserrated notch is very long, about one third of total length of blade; tip of latter smooth (Fig. 17I). Thoracic uncini saw-shaped with 5 or 6 teeth (Fig. 17J); anterior abdominal uncini similar with 4 or 5 teeth (Fig. 17K); posterior abdominal uncini are rasp-shaped. Anterior abdominal uncinal tori almost meet along the mid-dorsal line from about the 2nd to the 10th pair, after which the gap between them gradually increases. (Fig. 17B); capillaries commence from about the 85th.

Remarks. Although the operculum of *H. pseudexaltatus* is superficially similar to that of *H. exaltatus* (Marenzeller, 1885), the infundibular marginal processes are tapered and pointed in *H. exaltatus* (Figs 12C,E,F, 13A,B,L), whereas they end in swollen, somewhat T-shaped tips in *H. pseudexaltatus* (Fig. 17B–D). Moreover the coronal spines of *H. pseudexaltatus* lack medial processes (Fig. 17D), whereas in *H. exaltatus*, each coronal spine, including the enlarged one, bears a short pointed medial accessory process at about the level at which each main spine originates from its swollen base (Figs 12F, 13A,B). The bayonet collar chaetae of *H. pseudexaltatus* are characteristic in having a very long unserrated notch, which is about one third of the length of the blade (Fig. 17E–I); as also seen in the latter figures, the two teeth at the base of the blade originate way down along the boss compared to that in *H. exaltatus*.

Etymology. Named after the superficial similarity of its operculum to that of *H. exaltatus* (Marenzeller, 1884).

Hydroides simplidentatus n.sp.

Fig. 18A–J

Material examined. Holotype, AM W21415, Kimberleys, Western Australia, reef north-west of Buffon Island, 14°55'S 124°48'E, 20 m, coll. P.A. Hutchings, 23 Jul. 1988, st 85.

Description

Measurements. Worm incomplete posteriorly; width of thorax 0.5 mm; length of operculum and peduncle 2.5 mm, of operculum alone 1.0 mm.

Tube. Missing.

Worm. Thorax has dark brown pigmentation both dorsally and ventrally, and anterior to the thoracic tori; modified coronal spine translucent and off white, remaining coronal spines translucent and light brown. Modified dorsal spine vesicular, shaped like a swollen beak, curved towards the centre of the crown (Fig. 18A,B–F); remaining coronal spines number 6, highly reduced, pressed against base of the modified spine; their bases broad, but their short, simple, and

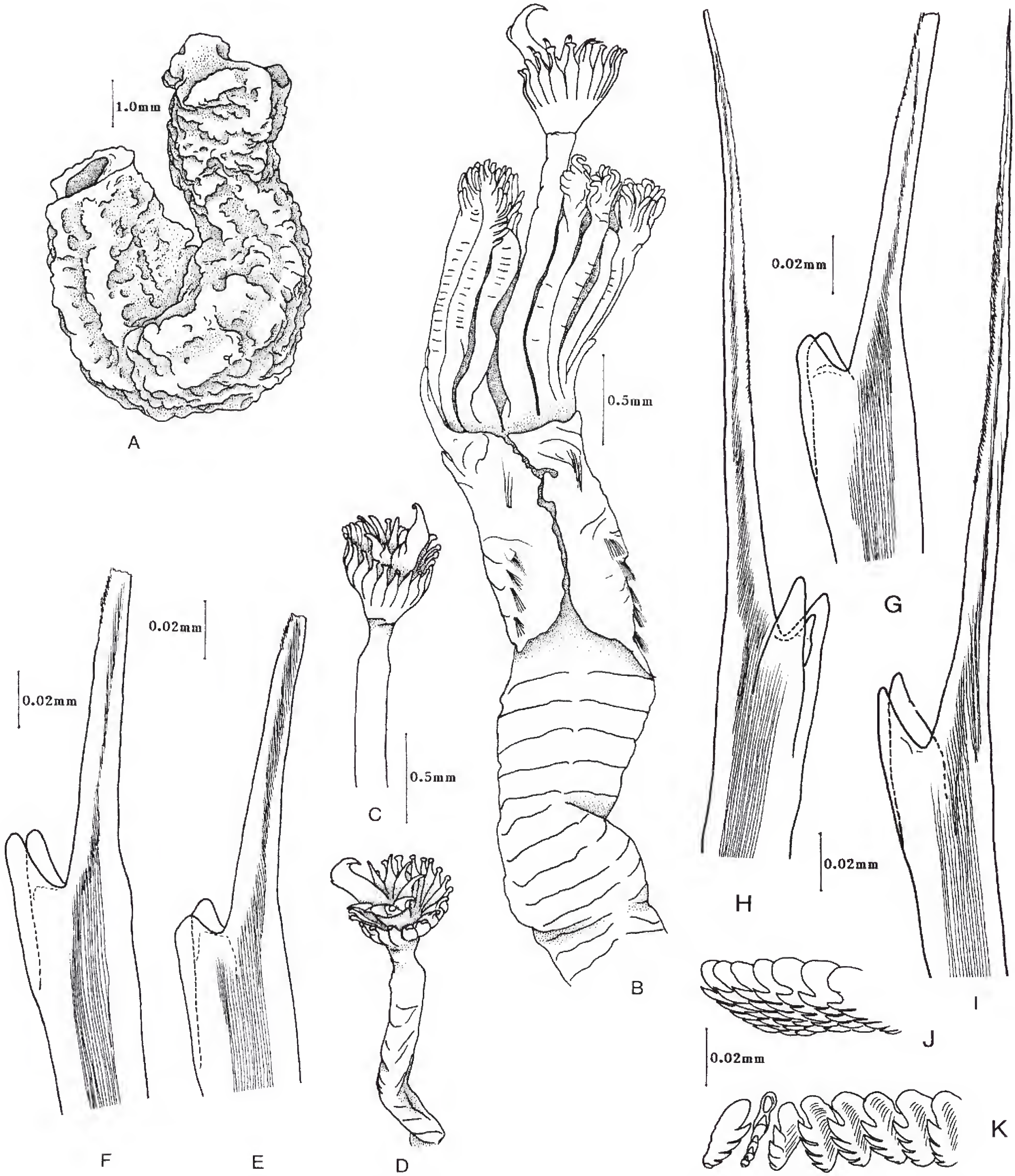

Figure 17. A–K, *Hydroides pseudexaltatus* n.sp., from holotype AM W202930. (*A*) tube; (*B*) anterior end of worm showing operculum, radioles, and anterior abdominal tori almost meeting dorsally; (*C,D*) two other views of operculum; (*E–I*) bayonet-shaped special collar chaetae; (*J*) thoracic uncini; (*K*) anterior abdominal uncini.

pointed tips directed outwards (Fig. 18A–D,F). Infundibular lobes number 16, their simple pointed tips black and directed outwards (Fig. 18A–F). Radioles: 7 pairs, operculum on right and a rudimentary operculum on left; their pinnule-free tips long and slender, about ⅕ of total length of radiole.

Chaetae. Special collar chaetae bayonet-shaped (Fig. 18G–I) bear two divergent conical processes at the base of the blade, their tips almost pointed; one to a few small accessory teeth present between them; unserrated notch moderately long. Thoracic uncini saw-shaped, and bear about 6 or 7 teeth in a single row (Fig. 18J, right figure); anterior abdominal uncini similar, with 4 or 5 teeth (Fig. 18J, left figure). Anterior abdominal uncinal tori: first 2–3 pairs separated by a small gap, rest dorsolateral, as seen in available part of abdomen (Fig. 18A).

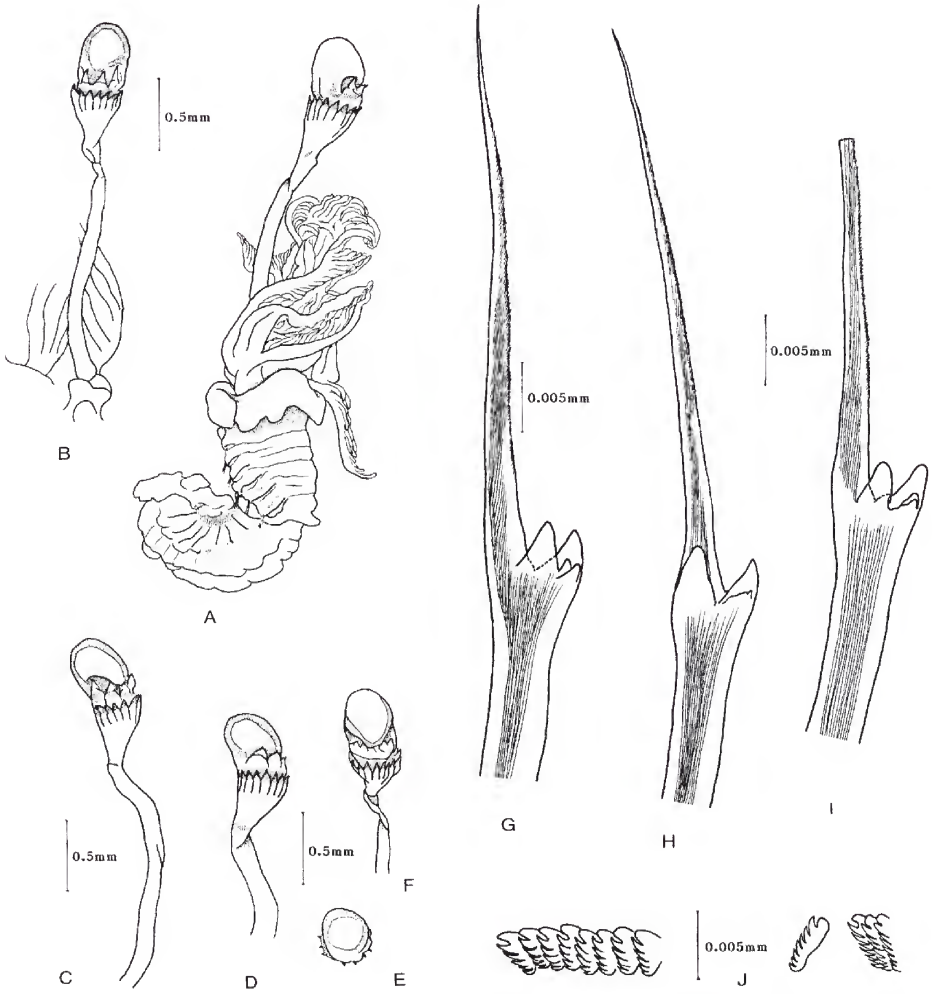

Figure 18. A–J, *Hydroides simplidentatus* n.sp., from holotype AM W21415. (*A*) anterior end of worm; (*B–F*) different views of operculum; (*G–I*) bayonet-shaped special collar chaetae; (*J*), (right of figure) thoracic uncini, and anterior abdominal uncini (left of figure).

Remarks. *Hydroides simplidentatus* n.sp. is somewhat similar to *H. brachyacanthus* Rioja, 1941. Sample BMNH 1933.7.10.445 collected by C. Crossland from Coiba Island, Pacific coast of Panama, and determined as *H. brachyacanthus* Rioja, 1941, by H. Zibrowius in 1970, was compared with the present species. Although its corona is superficially somewhat similar to that of *H. simplidentatus* (Fig. 38K–P), in that a modified spine is enlarged swollen and curved towards the centre of the corona, close examination shows that they are quite different. In *H. simplidentatus* it is vesicular, like a parrot's beak, hooked towards the centre of the crown, and enclosed in a translucent covering (Fig. 18A–D,F). In *H. brachyacanthus*, on the other hand, the enlarged spine with its pointed tip is bent at right angles. In *Hydroides* cf. *brachyacanthus* Rioja from Grenada (Bastida-Zavala & Hove, 2002: fig. 29a–f; 2003: fig. 3a–d) 1 or 2 enlarged coronal spines are directed ventrally. They are quite unlike the parrot beak-like modified coronal spine of *H. simplidentatus*, which is enclosed in a translucent covering. The structure of the remaining coronal spines in the two species is also very different. In *H. simplidentatus* they are in contrast, all the coronal spines in *H. brachyacanthus* are enlarged, although some may be simple, highly reduced, triangular, and having outwardly directed tips, conspicuously larger than the rest. They may also also have a knuckle-shaped bend and their blunt or pointed tips are directed towards the centre of the crown (Bastida-Zavala & Hove, 2002: fig. 29a–f; 2003: fig. 3a–d). According to the latter description (p. 154–155), "One dorsal spine is larger than the others, the rest gradually decrease in size (fig. 29b,d–f). Tip of spines pointed. Spines with one basal internal spinule (fig. 29f)…" Such basal processes are absent in the coronal spines of *H. simplidentatus*. Its modified coronal process lacks one, and there is no room left for them at the bases of the extremely reduced unmodified coronal processes which occur tightly pressed to the base of the modified coronal process.

Straughan (1967a) reports *S. brachyacanthus* from eastern Australia, also incorporating material described by Dew (1959) under the same species. The latter also superficially resembles *H. brachyacanthus* and *H. simplidentatus*, but it is different from both of them. A collection by Dew from Townsville, Queensland, BMNH 1959.10.19.61–62, and determined as *H. brachyacanthus*, sensu Dew, by H. Zibrowius in 1970, was examined during this study. In one specimen, 4 of the more dorsal coronal spines are larger that the rest and curved over the centre of the crown. One of the latter, in turn, is only slightly larger than the rest. However, Dew (1959) states that the crown consists of nine "stout inwardly-pointing spines, largest and stoutest of which curve over remaining eight, forming a cage." Dew's (1959) fig. 7B shows a single enlarged spine. It is evident that one or more enlarged coronal spines may be curved over the centre of the crown. While a shoulder can be faintly recognized in the four larger spines, they are strongly developed in the remaining coronal spines, being tooth-like as described by Dew (1959) and Straughan (1967a). Firstly, its main process is a strong curved spine (*vide* Dew, 1959: fig. 7B). Secondly, as described by Dew, "remaining spines, except pair flanking large spine, have a blunt, tooth-like projection on shoulder of curve". Straughan's (1967a) description is similar. In contrast, both *H. brachyacanthus* Rioja, 1941 and *H. simplidentatus* a single enlarged process curves over the centre of the crown. Further studies are required to determine whether Straughan's Eastern Australian material belongs to a species different from *H. brachyacanthus* Rioja.

Etymology. The specific name *simplidentatus* refers to the simple unmodified spines at the base of the enlarged coronal spine.

Hydroides spiculitubus n.sp.

Figs 19A–E, 20A–G, 21A–I

Hydroides tambalagamensis Pillai, 1961.—Straughan (1967b: 33, fig. 3g), Imajima (1976: fig. a–j) Imajima (1979: 167), Sun & Yang (2000: 128, fig. 6K–S), Imajima & ten Hove (1984: 49), Imajima & ten Hove (1986: 4).

Type material. Kimberleys, Western Australia. Type specimens: HOLOTYPE, AM W21443, Long Reef, 13°58'S 125°38'E, 25 m, 17 Jul. 1988, st 58. PARATYPES (2), first: AM W21468, south-west corner of Lucas Island, 15°13'S 124°31'E, 30 m, st 101. Second paratype: AM W21390, east side of Fenelon Island, 14°07'S 125°43'E, 6 m; all coll. by P.A. Hutchings, 18 Jul. 1988, st 64.

Description

Measurements. Appears to be very small species. Maximum tube diameter: 2.1 mm; total lengths: 9.7 mm, 10.3 mm and 14.8 mm, thoracic widths 1.0 mm, 1.0 mm and 0.7 mm. Specimen 1 has a single operculum, while 2 & 3 have two opercula each. Total lengths of their opercula and peduncles (the longer when two are present): 2.4 mm, 3.3 mm and 3.3 mm; their abdominal lengths and respective numbers of abdominal segments: 5.3 mm and 61 segments, 6.0 mm and 66 segments, and 8.6 mm and 86 segments. Commencement of abdominal capillaries in the three specimens, as follows: on segments 51, 55 and 69, respectively. Numbers of branchial radiole, respectively, as follows: 9 plus operculum on right, 8 plus no rudimentary operculum on left; 9 plus operculum on left and 9 plus operculum on right; and 10 plus operculum on left and 9 plus operculum on right.

Tube. White, with two dorsolateral longitudinal ridges separated by a moderately wide longitudinal gap which, together with the flange on either side, gives it a trapezoidal cross-sectional appearance (Fig. 19A–C); conspicuous transverse ridges and grooves present (Fig. 19A–C); a granular, semi-translucent, overlay present, especially along longitudinal and transverse ridges and flanks (Fig. 19A–D).

An unexpected character, hitherto unreported in any other *Hydroides* species, is the presence, in all three specimens, of a detachable inner tube (Fig. 19D). Under high examination, consists of transversely arranged, closely adposed, spicules (Fig. 19D,E) sloughed off from the ventral abdominal wall (Fig. 20A).

Worm. A brown pigment patch may be present in constriction between operculum and peduncle (Fig. 20C); ventral side of thorax and edges of thoracic membrane brown; a brown pigment band present anterior to each thoracic uncinal torus (Fig. 20A). Abdomen: a narrow pigment band present anterior to each torus, ending ventrally in a brown patch; a similar pigment band present across ventral side of each segment, joining corresponding ventral patches of both sides. One or two opercula may be present. Tips of coronal spines and their lateral spines, black. One specimen has a single operculum (Fig. 20B), the other, two well-developed opercula each (Fig. 20A). Three out of the 5 opercula among them, bear 7 coronal spines, the remaining two bear 6. All spines are similar (homospinous) and tapering; initially directed anteriorly and inclined towards the centre of the crown rather than outwards, then curved outwards before ending in curved pointed tips (Figs 20A–C, 21A–E). Located a little less than halfway along each spine and arising from it, externally, is a pair of short outwardly directed spines (Figs 20B,C, 21A–E). A medial spine is, present arising a little distal to the pair of lateral spines, as well as a basal process, both sharply hooked towards the base of the crown (Fig. 21D,E). Infundibulum: out of the five opercula amongst the three specimens one has 31 marginal processes, two 28, one 27, and one 26. Infundibular spines: transparent, their tips light brown; each marginal process has a sub-terminal knee-like bend towards centre of crown, beyond which it tapers to a simple pointed outwardly curved process (Fig. 21C). An aberrant condition occurs in one specimen, in which a single marginal infundibular process in one of its opercula is forked.

Maximum number of branchial radioles counted per side: 9 in all three specimens. However, specimen separated from AM W21390, has 11 radioles per side; their pinnule-free tips slender, and increase in length from ventral to dorsal radioles; about one-sixth of total length of radiole.

A light-brown cluster of prostomial ocelli present on each side, just anterior to the first pair of uncinal tori. Thoracic glands: absent. Anal segment bears a pair of brown to blackish clusters of ocelli (Fig. 20A,B,D,G).

Chaetae. Bayonet-shaped special collar chaetae (Figs 20E,F, 21F,G) possess two broad conical teeth at the base of the serrated blade. The unserrated notch is short. Thoracic and anterior abdominal uncini: saw-shaped, with 6 and 5 teeth, respectively (Fig. 21H,I); posterior abdominal uncini rasp-shaped. The anterior abdominal tori are dorsolateral, with a moderately wide gap separating them (Fig. 20B).

Remarks. The new species *H. spiculitubus* from the Kimberleys is only superficially similar to *H. tambalagamensis* from Sri Lanka with regard to the operculum. This has apparently led to the latter being reported from Southwest Japan by Imajima (1976: fig. 2a), and by Chen & Wu (2000: fig. 6K,L) from the waters off China.

Both species are similar in that their coronal spines are homospinous, and each bears a pair of short pointed spines located about halfway along its length, a short, inwardly

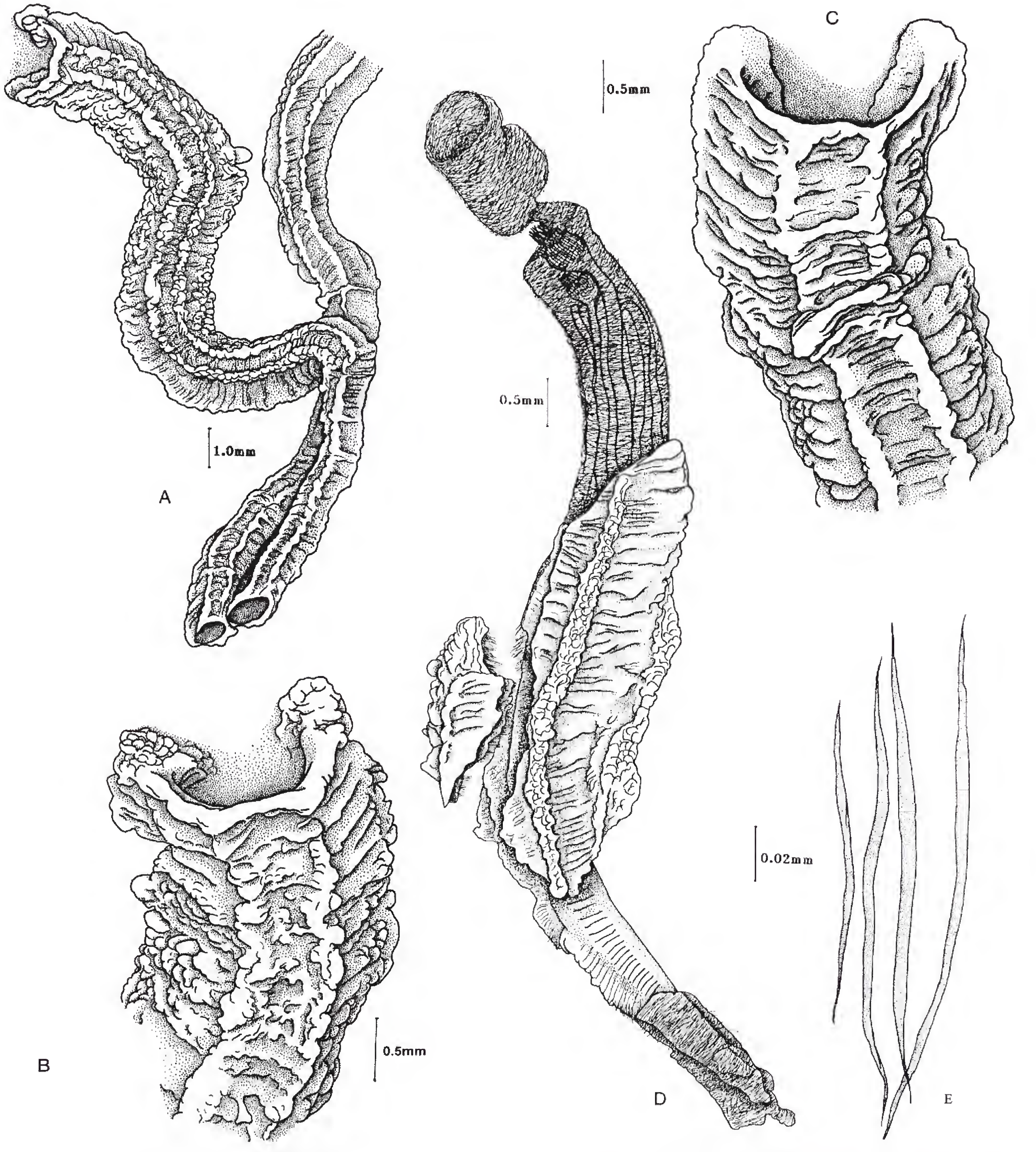

Figure 19. A–E, *Hydroides spiculitubus* n.sp. from AM W21443. (*A*) two tubes partly attached to each other; (*B,C*) magnified anterior ends of latter; (*D*) worm, in part of its tube: note non-calcareous inner tube consisting of closely adposed spicules, part of the detached inner tube folded over the posterior end of abdomen, the granular overlay along longitudinal ridges and the fine transverse ridges and grooves; (*E*) enlarged view of four spicules from inner tube.

curved, medial spine a little beyond them, and a basal spine. However, differences between them, following re-examination of the type specimen of *H. tambalagamensis*, BMNH 1960.3.13.30, are as follows. The coronal spines of *H. spiculitubus* are comparatively slender, directed anteriorly and meet sub-terminally, before curving outwards. In comparison, those of *H. tambalagamensis* are stout at their bases, rapidly tapering, directed outwards, and do not meet sub-terminally (*vide* Pillai, 1961: fig. 12A,B). The pair of spines in *H. spiculitubus* are external (Fig. 21A–C), whereas they are lateral in *H. tambalagamensis*, one on either side of each coronal spine (Pillai, 1961: fig. 12A,B). The medial spine of each coronal spine in *H. spiculitubus* is sharply hooked towards the centre of the coronal spines (Fig. 21D,E), in Imajima's Southwest Japan specimens (Imajima, 1976: fig. 2b) and in Chen & Wu's specimens form China (2000: fig. 6K). On the other hand, it is directed almost at right angles to each main spine in *H. tambalagamensis* is (Pillai, 1961:

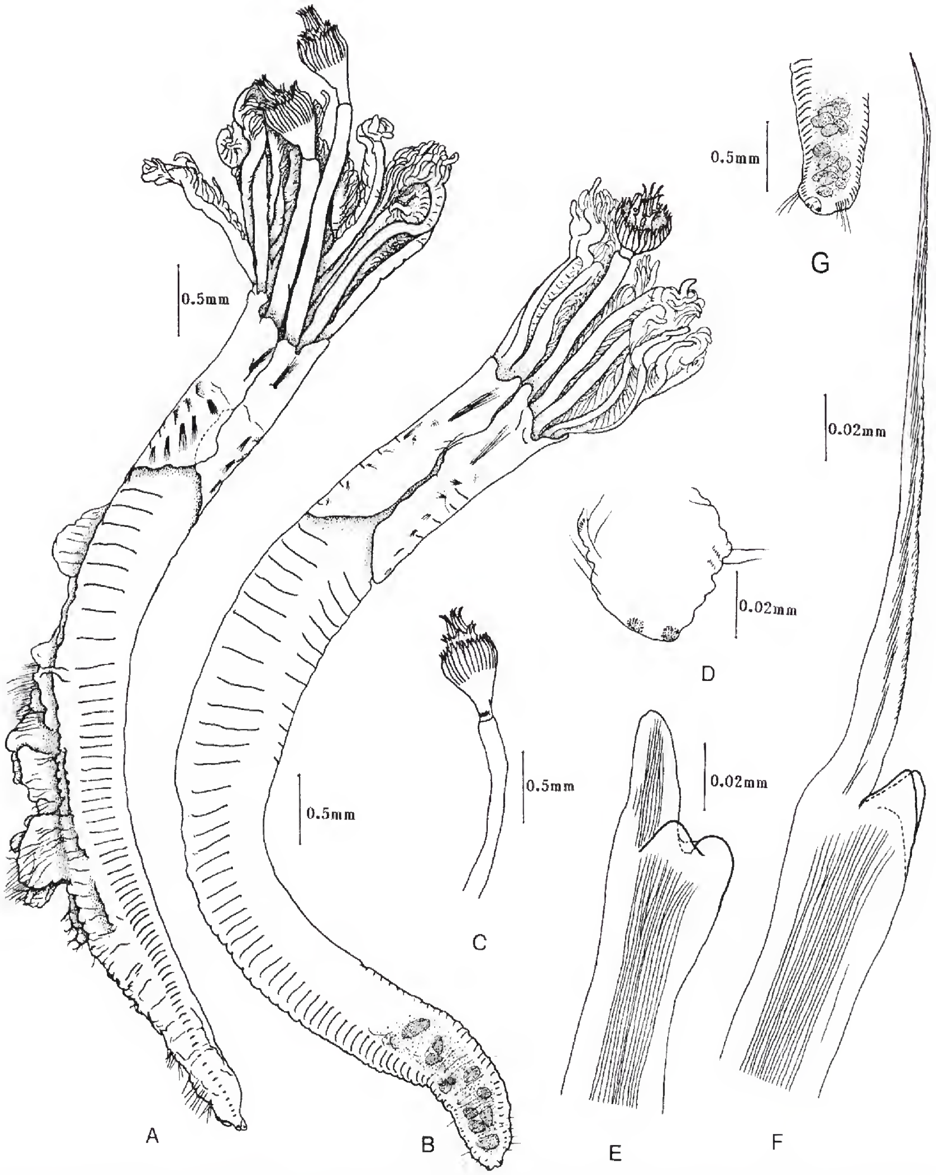

Figure 20. A–G, *Hydroides spiculitubus* n.sp.: from holotype AM W21443. (*A*) dorsolateral view of worm with two opercula showing spicules sloughed off from ventral side of abdomen, dorsolateral anterior abdominal tori and pair of eyespots on anal segment; (*B*) dorsolateral view of second specimen with a single operculum, showing dorsolateral arrangement of anterior abdominal tori and pair of anal eyespots; (*C*) operculum; (*D,G*) enlarged view of posterior ends of two worms showing the eye-spots on anal segment; (*E,F*) bayonet-shaped special collar chaetae.

fig. 12A,B). The basal process of each coronal spine in *H. spiculitubus* is slender, and acutely hooked towards the centre of the corona (Fig. 21D,E), whereas it is is obtusely triangular and blunt in *H. tambalagamensis* (Pillai, 1961: fig. 12B).

A further, very important difference between the two species is with regard to pinnule-free tips of radioles. In *H. spiculitubus* they are soft and similar in texture to that of pinnules (Fig. 20A,B), as also in almost all other serpulimorphs. However, as confirmed after re-examination of the type specimen during this study, each radiole in *H. tambalagamensis*, terminates in a stiff, chitinous colourless, inwardly curved, pointed hook (*vide* Pillai, 1961: 38, fig. 12C).

Anal eyespots are present in *H. spiculitubus*, but were not observed in the Southwest Japan material by Imajima (1976), material from China by Chen & Wu (2000), and *H. tambalagamensis* by Pillai (1961).

As described earlier, there are two important differences between the two species with regard to the tube. The first is the characteristic detachable inner tube of *H. spiculitubus*, composed of more or less transversely adposed chitinous spicules sloughed off from the ventral side of its abdomen (Fig. 19D), the function of which is obscure. In contrast, *H. tambalagamensis* has no such inner tube consisting of chitinous spicules as originally described by Pillai (1961). Imajima (1976) and Chen & Wu (2000) do not mention it in their descriptions of "*H. tambalagamensis*".

The second difference concerns the pair of longitudinal ridges along their tubes. In the material described as "*H. tambalagamensis*" from Southwest Japan by Imajima (1976: 123, fig. 2a–j) they are dorsolateral, separated by a relatively wide and shallow gap, which may also vary somewhat in width in different parts of the tube. Its granular overlay is concentrated along the longitudinal ridges and lateral edges of the tube. In *H. tambalagamensis* Pillai, 1961, on the other

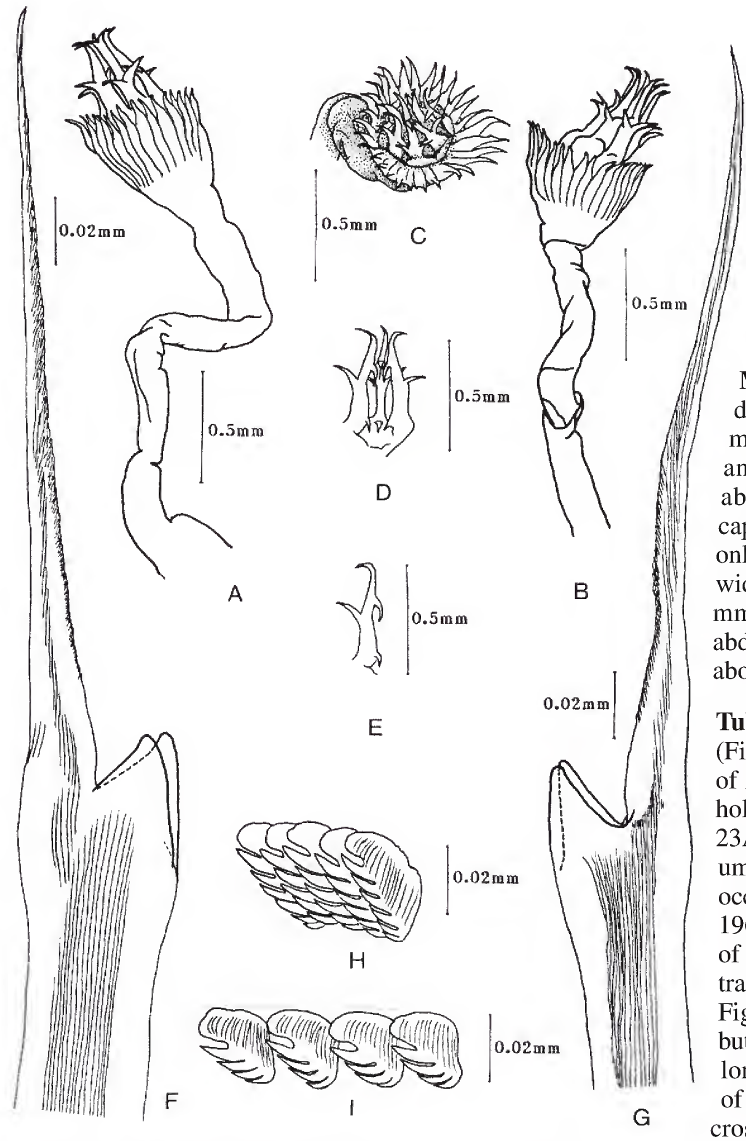

Figure 21. A–I, *Hydroides spiculitubus* n.sp.: from holotype AM W21443. (*A–C*) three different views of operculum; (*D*) longitudinal section operculum showing interior view; (*E*) structure of a coronal spine; (*F,G*) bayonet-shaped special collar chaetae; (*H*) thoracic uncini; (*I*) anterior abdominal uncini.

hand, and as confirmed after re-examination of the holotype during the present study, its two longitudinal ridges run along the crest of the tube rather than dorsolaterally, they are comparatively thicker, the longitudinal groove between them is narrower and deeper, as figured by Pillai (1961: fig. 12G). Its entire tube surface has a conspicuous granular overlay.

Confirmation is required as to whether an inner tube consisting of chitinous spicules occurs in "*H. tambalagamensis*" recorded from Queensland by Straughan (1967: fig. 3G), from Japan by Imajima (1976, 1979) and Imajima & Hove (1984, 1986), and from China by Chen & Wu (2000).

Etymology. Named after its characteristic inner tube constructed from chitinous spicules sloughed off from ventral side of the abdominal wall, occurring within the normal calcareous tube, within which the worm lives (Fig. 19D,E).

Hydroides spiratubus n.sp.

Figs 22A–F, 23A–J

Material examined. Kimberleys, Western Australia: HOLOTYPE: AM W21392, east side of Fenelon Island, 15°13'S 124°31'E, 30 m, 24 Jul. 1988, st 101. PARATYPE: AM W202955, east of Montalivet Island, 15°06'S 125°18'E, 6 m, 16 Jul. 1988, st 50, intertidal, found in a depression at the base of a piece of dead coral; both coll. by P.A. Hutchings.

Description

Measurements. Holotype: maximum external diameter of tube 1.2 mm; total length of worm 10.9 mm; thoracic width of 0.6 mm; length of operculum and peduncle 2.8 mm, operculum alone 1.0 mm; abdomen 6.5 mm, total number of segments 73, capillaries start from the 57th segment. Paratype: worm only only slightly smaller, 10.3 mm long, its thoracic width 0.4 mm, length of operculum and peduncle 2.7 mm, length of operculum alone 1.0 mm, length of abdomen 5.8 mm, and number of abdominal segments about 58; capillaries start from about 43rd segment.

Tube. Spirally coiled, in both holotype and paratype (Figs 22A, 23A), unlike in other hitherto known species of *Hydroides*. Coils laid obliquely upon each other in holotype (Fig. 22A), upon each other in paratype (Fig. 23A); bonded together in both; small tubeless area or umbilicus present in coil centre of both, similar to that occurring in certain species of *Spiraserpula* Regenhardt, 1961 (*vide* Pillai & Hove, 1994). In holotype, outer part of each coil white, its inner part consisting of a semi-translucent caramel-coloured band (stippled areas in Fig. 22A); paratype similar (stippled areas in Fig. 23A), but colour of its inner band lighter, almost white. Two longitudinal ridges may be discernible in certain parts of the tube where it may give it a more or less squarish cross-sectional appearance. A granular overlay present, more prominent along the longitudinal ridges.

Worm. Corona consists of 9 processes in both specimens; its modified dorsal process small, short, vesicular, and with a dorsolateral extension on each side and a medial swelling; T-shaped when viewed from anterior end (Fig. 22C,E); in lateral view, medial swelling is anteroventrally directed (Fig. 22B,D). Remaining coronal spines, as well as infundibular processes, end distally in somewhat T-shaped swellings (Fig. 22B,D,E). Holotype has higher number of infundibular processes, 25, the paratype 21. Radioles number 8 and 7 in holotype, 7 pairs in paratype, their pinnule-free tips long and conspicuous, about one-fifth the length of radiole (Fig. 22B). Prostomial ocelli: clusters of brown prostomial ocelli present. Thoracic chaetigers: 7 in both specimens. Thoracic glands: not discernible.

Chaetae. Bayonet collar chaetae (Fig. 23B–G) bear two large conical teeth at base, may also have 1 to a few smaller accessory teeth. Thoracic uncini rasp-shaped, possess 7 teeth (Fig. 23H); anterior abdominal uncini similar, usually with 5, sometimes 4, teeth (Fig. 23I); posterior abdominal uncini rasp-shaped. Anterior abdominal segments usually bear about 5 flattened trumpet-shaped neurochaetae; posterior abdominal neurochaetae almost capillaries, except that their tips are serrated along one side (Fig. 23J) as in many Serpulinae s.str.

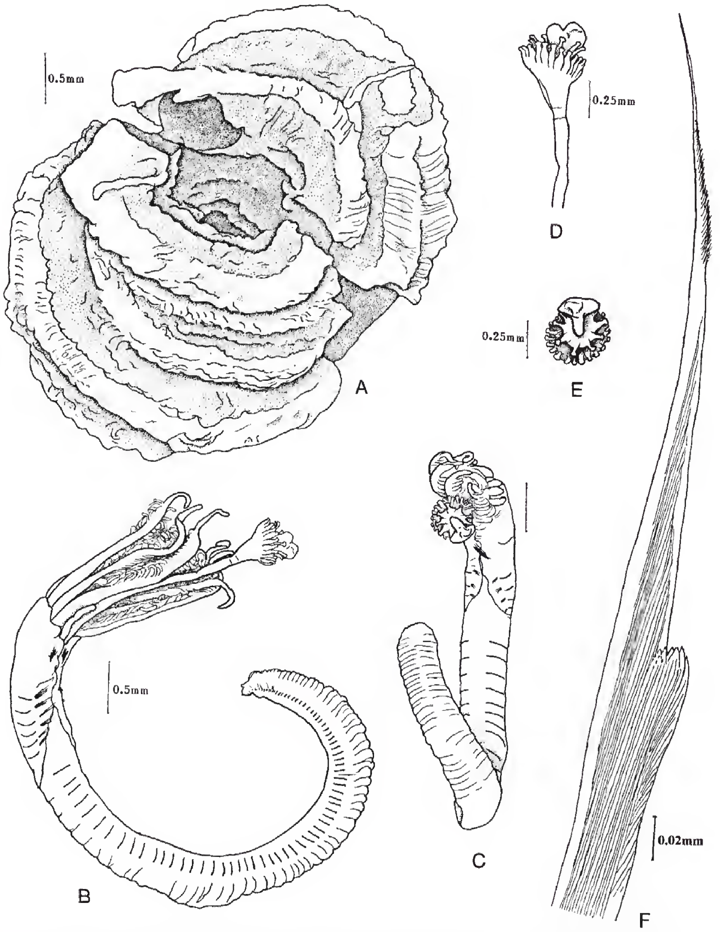

Figure 22. A–E, *Hydroides spiratubus* n.sp., from holotype AM W21392. (*A*) spiral tube; stippled areas represent the light caramel-coloured material laid along its concave sides; (*B*) worm removed from tube, showing the operculum, pinnule-free radiolar tips, and abdomen; (*C*) another view of worm showing arrangement of anterior abdominal tori; (*D*) lateral view of operculum; (*E,F*) vies of operculum; F, bayonet-shaped special collar chaeta of *Serpula narconensis* Baird, 1864, from holotype BMNH 1972.75, Narcon Island, *Erebus* and *Terror* Admiralty Southern Seas Expedition 1839–1843, for comparison with other Serpulinae, *sensu stricto*; note: it is unusual for members of the subfamily to have distally serrated special collar chaetae, i.e., serrated at the end of an extremely long unserrated notch.

Remarks. Like *Hydroides spiratubus* n.sp., three other species of *Hydroides* are known to possess a modified coronal spine that is T-shaped in cross-sectional appearance, together with unmodified coronal spines ending in swollen to T-shaped tips. They are, *H. albiceps* (Grube, 1870), *H exaltatus* var. *vesiculosus* Fauvel, 1923, from Îles Gambier, French Polynesia, and *H. trivesiculosus* Straughan, 1967, from Queensland.

Ten Hove kindly sent his extensive original notes and drawings on several collections of the above species, including those of his re-examination of specimens and type specimens described by various authors from Elat in Israel to locations in the Indo-West Pacific. They will be briefly referred to in the following discussion.

Willey (1905) and Pillai (1960) describe *H. albiceps* from Sri Lanka. However, the latter appears to be different from those those studied by ten Hove. Willey describes the coronal processes of a small specimen, only 7.0 mm long, from Galle (1905: 312, pl. VII, figs 180, 180a) as follows. It consists of "eight nearly erect slightly curved virgulae and a laterally compressed ovate lamina dorsalis, the latter being a direct continuation of the columella and bearing a pair of broad dorsolateral chitinous hamuli." Willey uses the diminutive plural "hamuli" of the Latin word "hamus", meaning hook, to describe the small lateral spine on each shoulder of the modified coronal process. He describes the corona of a larger specimen, 20.0 mm long as consisting of 7 processes, and that the modified coronal process (lamina dorsalis) as being "quite flattened except at the back." According to Willey's figure (1905: pl. VII, figs 180, 180a) the unmodified coronal processes are outwardly curved and pointed at their tips, and its infundibular processes do not end in swollen to T-shaped tips. Its modified coronal process is laterally flattened, except dorsally where it bears a pointed laterally directed "chitinous" spine on each shoulder. Pillai's description and figures (1960: fig. 4F–M), based on a collection of 33 specimens from the Pearl Banks, agrees with that of Willey (1905) with regard modified and unmodified coronal processes and the infundibular processes. Tubes are "quadrilateral in cross-section", the attached side being wider than the flattened opposite side, and the two upper angles of the latter being sometimes drawn out into low lateral longitudinall ridges. No spirally coiled tubes were observed. Bayonet-shaped special collar chaetae possess two conical processes at the base of the blade. Throracic uncini bear about 7 teeth in a single row.

Although the collections studied by ten Hove: PHYT 3436 from El Bilyayim, Gulf of Suez, and the following collections from Elat: NS 2149; 61–73; NS2148 RS TAV; NS2142 TAV; NS2145 TAV, and Elat8 are superficially similar to those described by Willey and Pillai from Sri Lanka, there are three differences between them. Firstly, the modified coronal process of the former does not possess the pair of pointed mediolateral spines that occur in the latter. Secondly, the unmodified coronal spines of the former end in swollen to T-shaped tips, whereas they are simple, outwardly directed and pointed in the latter. Thirdly, the tips of the infundibular radii in in the former vary from being pointed to somewhat swollen, whereas they are simple and pointed in the latter. The numerous specimens of *H. albiceps* examined and figured by ten Hove from collections in the AM, Sydney, from Australia (Lizard Island, Townsville, Barney Point, Gladstone, Shoal Point, Tannum Sands, Burleigh, Cairns, Pats Point, Mackay, Noosa Heads, York Peninsula and Port Moresby), and Ambon, also agree with the non-Sri Lankan collections discussed above. Ten Hove does not describe spirally coiled tubes in any of the collections examined, a characteristic of *H. spiratubus* n.sp. But according to his drawings of the tubes from AM W3975 (Barney Point, Gladstone) AM W3960 (Shoal Point) and AM W3961 (Tannum Sands) are trapezoidal in cross-section and bear a pair of longitudinal ridges.

The second species that needs to be compared with *H. spiratubus* n.sp., is *H. exaltatus* var. *vesiculosus* Fauvel

Figure 23. A–J, *Hydroides spiratubus* n.sp. (*A*) tube of paratype AM W202955. B–J, from holotype AM W21392: (*B–G*) bayonet-shaped special collar chaetae; (*H*) thoracic uncini; (*I*) anterior abdominal uncini; (*J*) tip of posterior abdominal chaeta.

(1923: 50, 1953: 641) from French Polynesia. Fauvel distinguished it from *H. exaltatus* (Marenzeller, 1884) on the basis that its modified coronal process is "a large hollow vesicle" which "takes the place of the great unpaired hook." Fauvel (1923) adds that *H. exaltatus* var. *vesiculosus* "is a connecting link between *H. exaltatus* (Marenzeller) and *H. albiceps* (Ehrenberg)." However, Fauvel's specimens from French Polynesia differ from both *H. spiratubus* and *H. trivesiculosus* in having a significantly higher numbers of coronal processes. According to Fauvel (1923: 49), they number about a dozen "Les dents du calice supérieur, au nombre d'une douzaine, sont subégales recourbées en dehors et terminées croc émoussé sans pointes laterales."

The third species that needs to be compared with is *H. trivesiculosus* Straughan, 1967. The corona of the former (Fig. 22B–E) consists of 9 processes (in both holotype and paratype). Its modified dorsal process is small, short, vesicular, and has a dorsolateral extension on each side as well as a medial swelling. Its unmodified coronal spines end distally in swollen tips. On the other hand, based on Straughan's study of 6 specimens (1967: 34, fig. 3H,I), the corona of *H. trivesiculosus*, consists of only 5 processes. The modified process is massive, trivesicular in cross-sectional appearance and elongated, while the 4 unmodified processes are like tiny appendages at the base of the latter, ending in minute pinhead-like swollen tips.

Ten Hove's studies and drawings referred to above include collections both identified and misidentified as *H. tivesiculosus* Straughan, 1967, as well as un-identified material from various localities. Those identified as *H. tivesiculosus* are, from Australia: Heron Islands (AMF, det. Straughan), and Lizard Island. Among misidentified ones: BMNH 1870.12.23.63, as *Eupomatus albiceps* (Grube, 1870) from the Red Sea, Gulf of Suez, legit. J.K. Lord, separated by H. Zibrowius from *Spirobranchus giganteus* in 1970; Nat. Hist. Mus. LA, one incomplete specimen, as *H. albiceps* by Straughan, from Port Douglas, Qld, which, according to ten Hove's notes is "with typical operculum" (of *H. trivesiculosus*). Non-type material identified as *H. trivesiculosus* consist of a loose dried up operculum from Heron Island in Nat.Hist.Mus. LA. The unidentified material determined as *H. trivesiculosus* are BMNH from Kunduchi Island, collected by Pillai, 28.08.1981 and ZMK, from the Java Strait. In general, they all agree with Straughan's description of *H. trivesiculosus* summarized in the preceding paragraph.

Characters relating to the tube of *H. spiratubus*, that distinguish the latter from both Fauvel's species from French Polynesia and *H. trivesiculosus* from Queensland, are as follows: tube of *H. spiratubus* is spirally coiled, its coils bonded together; and possesses an umbilicus (see under description of tube and Figs 22A, 23A). Fauvel (1923: 49, fig. 7) describes that of the French Polynesian species as being loosely coiled: "tube blanchâtre, faiblement bosselé, sans ornementation speciale, est lâchement enroulé sur la coquille d'une Huître perlière." Tubes of many serpulids may be sinuous or loosely coiled. Tube of "*H. albiceps*" from Sri Lanka, as well of the above collections studied by ten Hove, is quadrilateral to trapezoidal in cross-section and usually bears a pair of longitudinal ridges.

Etymology. Named after the spirally coiled tube.

Hydroides trihamulatus n.sp.

Figs 24A–G, 25A–C, 26A–L

Material examined. Kimberleys, Western Australia: 4 specimens, AM W21412, sand cay on Port George IV, 15°20'S 124°39'E, 12 Jul. 1988, st 26, of which 1 lacks part of its tube and posterior end of its abdomen; two lack their tubes and consist of anterior ends only; and one consists of radiolar crown of one side only. 5 specimens, AM W202944, sand cay on Port George IV, 15°20'S 124°39'E, 12 Jul. 1988, st 26; all coll. by P.A. Hutchings.

Juveniles. 2 specimens, AM W202944, sandy cay on Port George IV, 15°20'S 124°39'E, 12 Jul. 1988, st 26; 1 specimen, AM W21469, south west corner of Lucas Island, Kimberleys, Western Australia, 15°13'S 124°31'E, 30 m, 24 Jul. 1988, st 101. 1 loose radiolar crown from one side only plus operculum, AM W202939, sandy cay on Port George IV, 15°20'S 124°39'E, 12 Jul. 1988, st 26. 1 specimen, AM W202944, sandy cay on Port George IV, 15°20'S 124°39'E, 12 Jul. 1988, st 26 (table 14, no. 4). 1 specimen lacking tube, AM W202943, reef north west of Buffon Island, 14°55'S 124°48'E, 12 Jul. 1988, st 26; all coll. by P.A. Hutchings.

Description

Measurements. From AM W21412: largest tube diameter 1.5 mm; thoracic width in three specimens 1.0 mm; maximum; length of operculum and peduncle 3.7 mm; length of operculum only 0.9 mm. Maximum number of branchial radioles observed 10 per side. Number of abdominal segments could not be determined since worms are incomplete posteriorly; however, 25 could be counted in the available anterior part in one specimen. Total length of highly coiled worm from AM W202943 without its tube: 9.9 mm; width of thorax 1.0 mm, length of operculum and peduncle 3.0 mm, length of operculum 1.3 mm, length of abdomen 5.3 mm, and number of abdominal segments about 55. A smaller specimen 4.8 mm long has 51 abdominal segments, with capillaries commencing on about the 40th segment.

Tube. White in juveniles, dull white in older specimens; squarish to trapezoidal in cross-section; possesses two longitudinal ridges with a comparatively wide longitudinal depression between them (Figs 24A,B, 26A–C), which may only be faintly developed (Fig. 24E). A granular overlay is present along certain areas (Fig. 24A,B,E); may be faint in some specimens.

Worm. Operculum on either left or right side; light caramel coloured, its cuticle transparent. Number of coronal spines range from 11–15; number of infundibular lobes 17 to 24. Coronal and infundibular spines show variations associated with ontogenesis. In infundibular spines of early juveniles (Fig. 24D,F), their tips are simple and pointed. Modified modified coronal spine becomes larger than the rest, develops a translucent medial swelling, and ends in a pair of blunt outwardly directed processes (Fig. 24C,D). Unmodified coronal spines: outwardly directed and devoid of basal spines. Infundibular spines may remain simple and pointed while coronal spines become swollen at their tips, foreshadowing the T-shaped tips of later stages, while the medial swelling and forked tips of the modified coronal spine become more prominent (Fig. 24F). In a later stage (Fig. 24G), both infundibular and coronal spines are T-shaped; and medial and the two terminal processes of the modified coronal spine become even more prominent (Fig. 24G).

The adult worm shown in specimen from AM W202943 (Fig. 25A) has 9 radioles plus rudimentary operculum on left, and 8 plus operculum on right. The smaller specimen mentioned under measurements has 6 radioles per side. Although 11–15 coronal spines were counted in juveniles, only 10 are present in the present adult specimen, making their range in the present collection from 10–15; all devoid of a basal process. The medial process of modified coronal spine is a firm, beak-like process, curved towards the centre of the crown (Fig. 25A–C). Both processes at the distal end of the modified coronal spine are fully developed, their tips pointed and laterally curved (Fig. 25A–C). Infundibular radii number 19. While the tips of the unmodified coronal spines and the marginal infundibular processes are T-shaped or end in rounded tips in later juveniles, they are anchor-shaped and with pointed transparent laterally directed tips in adults (Fig. 25A–C).

Chaetae. Bayonet-shaped special collar chaetae (26G–J) possess two main conical processes at the base of the blade

Erratum. Types not designated, therefore name unavailable—see Murray *et al*., 2010.
Murray, Hutchings & Pillai, 2010. Note on *Hydroides malleolaspinus* from the Kimberleys of Western Australia (Polychaeta: Serpulidae). *Records of the Australian Museum* 62(3): 393–394, doi:10.3853/j.0067-1975.62.2010.1564. [Editor—6 Dec. 2010]

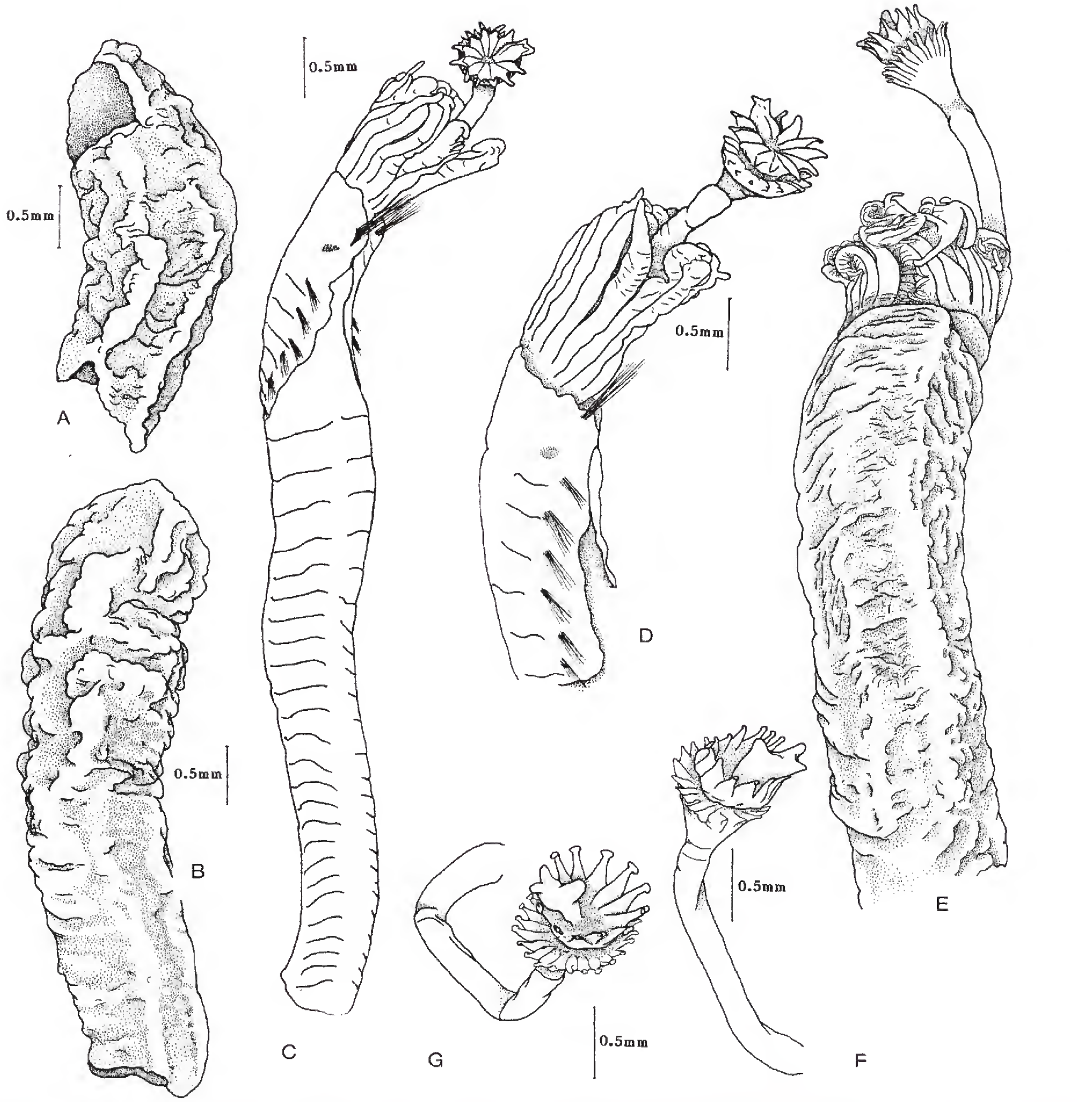

Figure 24. A–J, *Hydroides trihamulatus* n.sp. (*A,B*) anterior and posterior parts of tube of a juvenile specimen; (*C*) worm, showing operculum, operculum, pinnule-free tips of radioles and arrangement of anterior abdominal tori; D–F, from another somewhat older specimen: (*D*) anterior end of worm, showing operculum, its well-formed main coronal spine, and remaining coronal spines and infundibular spines with simple pointed tips; (*E*) tube with worm *in situ*; (*F*) operculum showing somewhat swollen processes; (*G*) operculum of still older specimen showing well-formed main coronal spine and remaining coronal and infundibular spines with T-shaped tipas.

and 1 or 2 small accessory teeth between them; unserrated notch short, about ¼ length of blade. Thoracic uncini: saw-shaped, with 6–7 teeth in a single row (Fig. 26K); anterior abdominal uncini similar, with 4 or 5 teeth (Fig. 26L); posterior abdominal uncini rasp-shaped. Anterior abdominal uncinal tori of the two sides are separated by a narrow gap (Fig. 24C); which is wider in juveniles (Fig. 26D).

Remarks. The new species, *Hydroides trihamulatus* is apparently similar to *H. malleolaspina* Straughan (1967: 222, fig. 7a–f), originally described from Queensland, with regard to the T-shaped infundibular and modified coronal spines. However, it is different with regard to the modified coronal spine. Straughan (1967) describes the latter in *H. malleolaspina* as being hammer-shaped distally and lacking a medial process, whereas, in *H. trihamulatus*, it ends in a bifid tip and bears a medial hooked process. Although the medial process and both processes at the distal end of the modified coronal spine are soft and blunt in juveniles of the present species (Fig. 24C–F), they are firm and beak-like in adults (Fig. 25A–C). *Hydroides rectus* Straughan (1967: 225, fig. 8a–f) differs from both *H. malleolaspina* and *H. trihamulatus* in that its unmodified coronal spines and infundibular spines are not T-shaped but tapered and pointed distally, as described and figured by Straughan (1967: 225, fig. 8b–d). Moreover, the modified coronal spine of *H. rectus* is not bifid at its tip as in *H. trihamulatus*, but has a process at its distal end, which appears to be at right angles to it and directed towards the centre of the crown.

Imajima & ten Hove (1984: 45–47) discuss *H. novaepommeraniae* Augener, 1925; *H. grubei* Pillai, 1971, *H. malleolaspina* Straughan, 1967, *H. recta* Straughan, 1967, and *H. ancorispina* Pillai, 1971, and conclude by recognizing the following three species in the Indo-Pacific region.

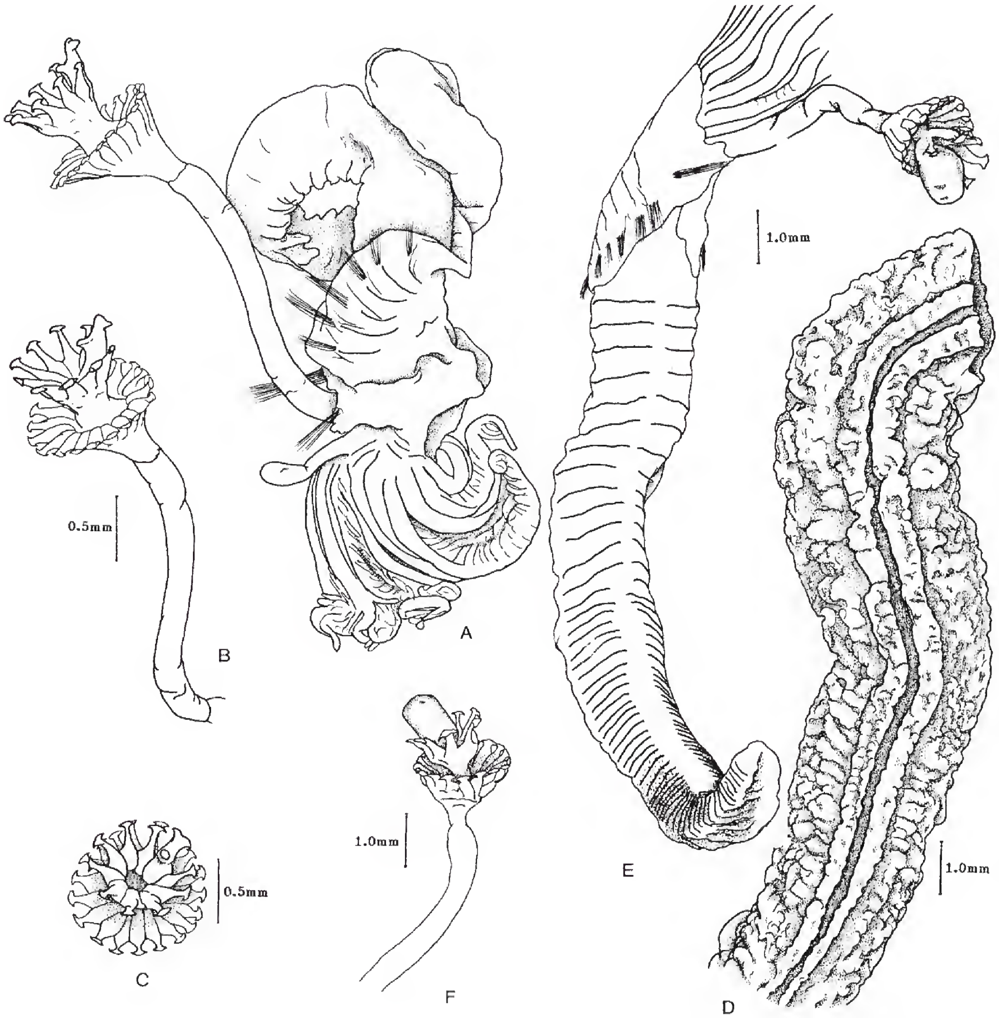

Figure 25. A–C, *Hydroides trihamulatus* n.sp.—an older specimen from AM W202943: (*A*) anterior end of worm showing structure of adult operculum; (*B,C*) two more views of same operculum. D–F, *Hydroides ancorispina* Pillai, 1961: (*D*) tube, note the granular overlay and the pair of longitudinal ridges running along the crest of the tube, with a narrow groove between them; (*E*) worm showing operculum and arrangement of anterior abdominal tori; (*F*) another view of operculum.

Hydroides novaepommeraniae (including *H. grubei* and *H. malleolaspina* sensu Imajima [1982]); *H. malleolaspina* Straughan: (including *H. ancorispina* Pillai) and *H. recta* sensu Dew (1959). Ten Hove (1994: 108) and Fiege & Sun (1999: 114) include *H. ancorispina* in the "*H. ancorispina/ malleolaspina* complex". The holotype of *Hydroides ancorispina* Pillai, 1971: BMNH 1968.148 was, therefore, re-examined during the present study. Its operculum as described by Pillai (1971: fig. 6A,B); and (Fig. 25D–F), in the present paper, is very different from that of *H. malleolaspina* Straughan (1967: 222, fig. 7a). The modified coronal spine of the former is a smooth, somewhat laterally compressed column, and totally lacks both medial and terminal processes. It does not possess a sub-terminal constriction before its hammer-shaped end as in *H. malleolaspina* (Straughan, 1967: fig. 7a), and also does not end distally in a beak-like medial projection as in specimens from the South China Sea described- as *Hydroides ancorispina/malleolaspina* by Fiege & Sun (1999: 114, fig. 5A,B), although it is superficially similar. Sun & Yang (2000: 124, fig. 5A,B) give a good description of the operculum of *H. malleolaspina* from the waters off China. *Hydroides ancorispina* possesses a corona with seven processes including the modified columnar process (Pillai, 1971: 108, fig. 6B), while *H. malleolaspina* has a higher number, 10, recorded by Straughan (1967: 222), including the hammer-shaped modified coronal process. Hence *H. ancorispina* is considered to be distinct a species from *H. malleolaspina* in the present account. Incidentally, the modified columnar coronal process of *H. ancorispina* is iridescent, a character overlooked before, even after more than 30 years in alcohol.

Etymology. The specific name *trihamulatus* refers to the 3 chitinous hooks borne by the modified coronal process in adults, one medial and curved towards the centre of the crown, and the other two located terminally and directed laterally.

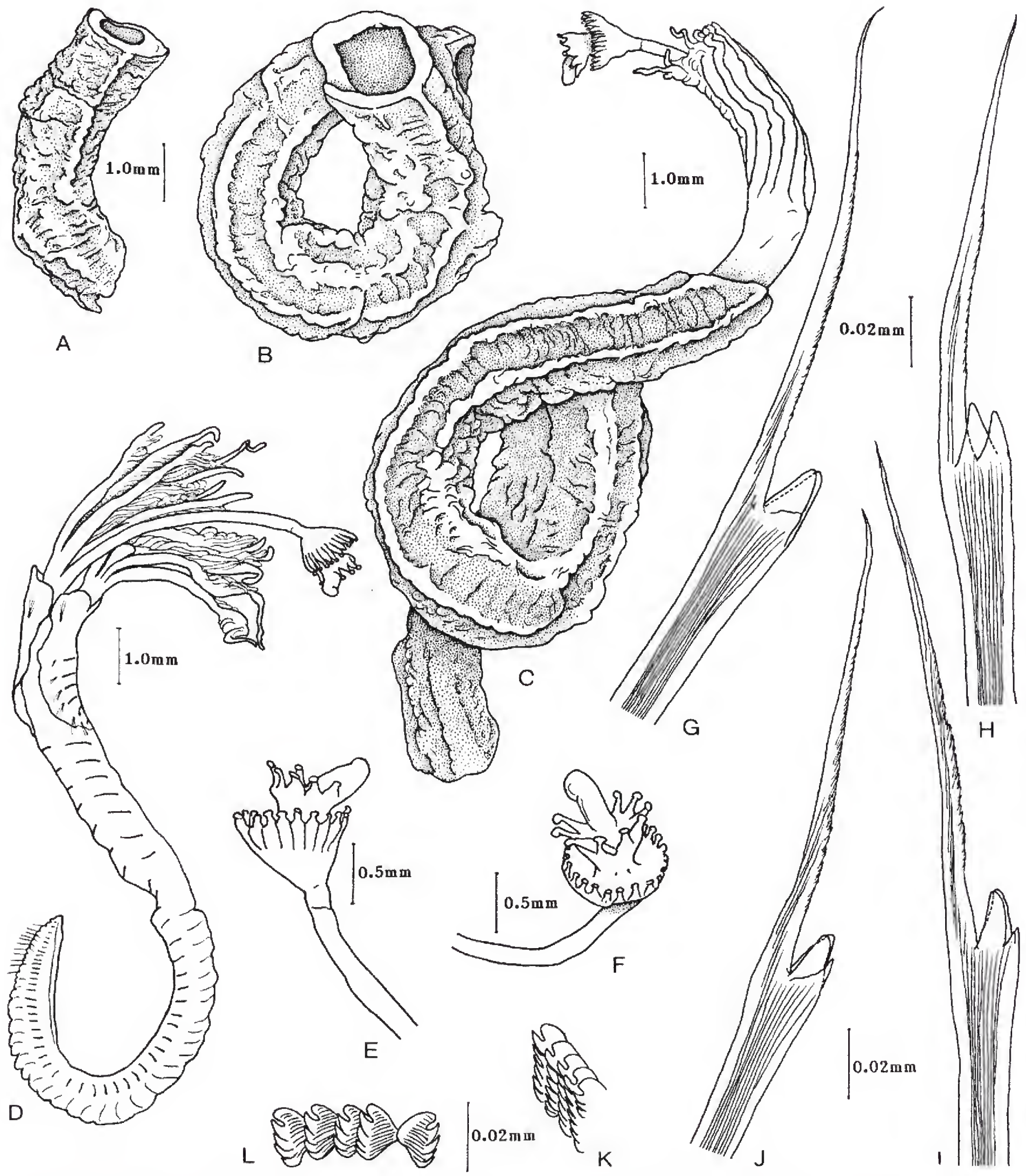

Figure 26. A–K, *Hydroides trihamulatus* n.sp., specimen from AM W202944: (*A,B*) anterior parts of tube; (*C*) part of tube with worm *in situ*; (*D*) worm removed from its tube; (*E,F*) enlarged view of operculum, note swollen tips of unmodified coronal spine and infundibular spines; (*G–J*) bayonet-shaped special collar chaetae; (*K*) anterior abdominal uncini; (*L*) thoracic uncini.

Genus *Serpula* Linnaeus, 1758

Type species. *Serpula vermicularis* Linnaeus, 1767

Diagnosis. Operculum chitinous; funnel-shaped, bearing dichotomous radii ending in marginal lobes; inserted in position of second branchial radiole; peduncle non-pinnulate; inter-radiolar membranes absent. Number of thoracic chaetigers: seven. Apron: present. Special collar usually bayonet shaped, bearing two to a number of teeth on boss. Most anterior uncinal tooth: larger than the rest. Distal ends of abdominal neurochaetae shaped like asymmetrically "flattened trumpets", with one side longer than other, and bear numerous serrations or denticulations. Tube: devoid of internal tube structures.

Remarks. The shape and range in number of the radial lobes in adult opercula, besides other characters, are useful in distinguishing species belonging to the genus.

Serpula amplilobata n.sp.

Figs 27A–K, 28A–E

Material examined. Kimberleys, Western Australia, HOLOTYPE: AM W21410, east Montalivet Island 15°06'S 125°18'E, 6 m, 15 Jul. 1988, st 50; coll. P.A. Hutchings.

Description

Measurements. Maximum external diameter of tube 3.7 mm, width of thorax 1.2 mm, length of operculum and peduncle 5.7 mm, length of operculum 2.1 mm, diameter of operculum 1.5 mm, width of thorax 1.2 mm; worm incomplete posteriorly.

Tube. White; coiled upon itself; possibly with a non-coiled part preceding the coiled part; mutually bonded coils; a conspicuous translucent granular overlay present (Fig. 27A) and two rounded longitudinal ridges.

Worm. Holotype, operculum on right, rudimentary operculum on left (Fig. 27B); operculum bell-shaped, its proximal part rounded; number of radial lobes comparatively small, 17; broad, rounded, and with a thick translucent cuticle (Fig. 27B,C); tubercles absent; constriction between operculum and peduncle sharp. Number of radioles: 17 on each side, their pinnule-free tips not significantly different from pinnules (Fig. 27D). A large cluster of reddish prostomial ocelli present on each side. Abdomen: incomplete posteriorly.

Chaetae. Bayonet-shaped special collar chaetae (Figs 27E–I, 28A,B) bear two large acutely triangular to conical teeth at the base of blade; some bayonet-chaetae may have a smaller accessory tooth in between (Fig. 27F,G). Unserrated notch: short in older bayonet chaetae (Fig. 27E–I), moderately long in newly formed ones within collar fascicles (Fig. 28A). Thoracic and anterior abdominal uncini: saw-shaped, bear 4 or 5 teeth (Figs 27J,K, 28D,E). Anterior abdominal uncinal tori: dorsolateral, with a wide gap separating corresponding pairs; gap about half the length of an uncinal torus in the region of the 6th to 10th abdominal segments (Fig. 28C).

Remarks. The differences among *Serpula amplilobata* and the other species of *Serpula* dealt with in this paper, namely, *S. jukesii* Baird, 1865, *S. nudiradiata* n.sp., and *S. watsoni* Willey, 1905, are as follows. (*a*) Its tube is coiled upon itself and mutually bonded together, whereas those of *S. jukesii, S. nudiradiata*, and *S. watsoni* are not. (*b*), The operculum in *S. amplilobata* and *S. watsoni* is bell-shaped, whereas that of *S. jukesii* is funnel-shaped. (*c*) The operculum of *S. amplilobata* bears a few comparatively large radial lobes, whereas that of *S. nudiradiata, S. jukesii* and *S. watsoni* bears a relatively large number. (*d*) The opercular cuticle in *S. amplilobata* is thick and translucent, as seen in the grooves between and tips of opercular radii, whereas it is not so in *S. nudiradiata* and *S. jukesii* and *S. watsoni*. (*e*) The opercular radii of *S. amplilobata* and *S. nudiradiata* are devoid of tubercles, whereas those of *S. jukesii* and *S. watsoni* bear tubercles. (*f*) The proximal part of the operculum in *S. amplilobata* and *S. watsoni* is bulbous, whereas that of *S. jukesii* is tapering (as in other *Serpula* spp. with funnel-shaped opercula). (*g*) The constriction between the operculum and peduncle is sharp, in *S. amplilobata* and *S. watsoni*, whereas whereas it is not so in *S jukesii*.

Etymology. The specific name *amplilobata* is derived from the Latin *amplus* = large and the Greek *lobos* = lobe, to describe the large rounded marginal lobes at the end of the opercular radii. They are few in number and much larger in size compared to those in species such as *S. jukesii* and *S. nudiradiata*.

Serpula jukesii Baird, 1865

Figs 27F–H, 28A–F

Serpula jukesii Baird, 1865: 20, fig. 6.
Serpula magna.—Straughan (1967a: 208, fig. 3c–h).
?*Serpula vermicularis*.—Straughan (1967b: 30).

Material examined. Kimberleys, Western Australia, 3 specimens, AM W21395, AM W29691 and AM W21394 from east side of Fenelon Island, 14°07'S 125°43'E, 6 m, 18 Jul. 1988, st 64; coll. by P.A. Hutchings.

Description

Measurements. Tube of specimen in AM W21934 has the larger maximum external diameter of 9.0 mm and thickness of 1.05 mm. Measurements of two larger worms, respectively, as follows, total lengths: 30.7 mm and 40.0 mm. Thoracic widths 5.7 mm and 4.7 mm. Lengths of operculum and peduncle 10.9 mm and 9.2 mm. Lengths of the opercula alone, 5.1 mm and 4.5 mm. Distal end of operculum is not perfectly circular; hence the larger and smaller diameters in the first specimen are 5.6 mm and 5.0 mm. Abdomen in one specimen is 19.8 mm long, has 175 segments with capillaries commencing from the 137th segment; 24.6 mm long in the second, and has 155 segments, with capillaries commencing from the 124th and 60 plus the operculum on the right; it is slightly higher in the second specimen, which has 62 radioles plus the operculum on the left and 56 plus the rudimentary operculum on the right. Pinnule-free tips are very short, slightly thicker than the pinnules. Prostomial ocelli and thoracic glands absent; an apron is present. In the first specimen, the abdominal segments number 175 and capillaries start from segment 137; 155 segments in the second.

Tube. Whitish to caramel coloured and thick; three faint longitudinal ridges present in some places; four closely formed peristomes present anteriorly in first specimen (Fig. 28F).

Worm. Operculum funnel-shaped. As seen from measurements, its distal part is nearly circular, somewhat wider in a dorsoventral direction than laterally, its maximum diameter greater than length of funnel (Figs 28G, 29A). Number of radial lobes 75 in first specimen, 77 in second, bluntly triangular; cuticle thin, tubercles present along radii (Fig. 29A). Proximal part of funnel elongated, gradually decreases in diameter to where it joins the peduncle; constriction between operculum and peduncle faintly recognizable (Figs. 28G, 28A). First specimen has 58 radioles plus rudimentary operculum on right; 60 plus operculum on right; higher in second specimen, with 62 plus operculum on left, and 56 plus rudimentary operculum on right. Pinnule-free tips of radioles: very short; slightly thicker than pinnules. Prostomial ocelli and thoracic glands: absent. Apron: present.

Chaetae. Special collar chaetae bayonet shaped, and bear 2 or 3 conical processes at base of blade (Fig. 29B); may be considerably abraded in older chaetae Fig. 29D). Unserrated notch, as seen in chaetae from deep within fascicle short to moderately long, about twice as long as teeth on boss (Fig. 29B,C), long in older chaetae (Fig. 29D). Thoracic uncini: saw-shaped, with 5 teeth in single row (Fig. 29E); anterior abdominal uncini similar, with 4 or 5 teeth (Fig. 29F).

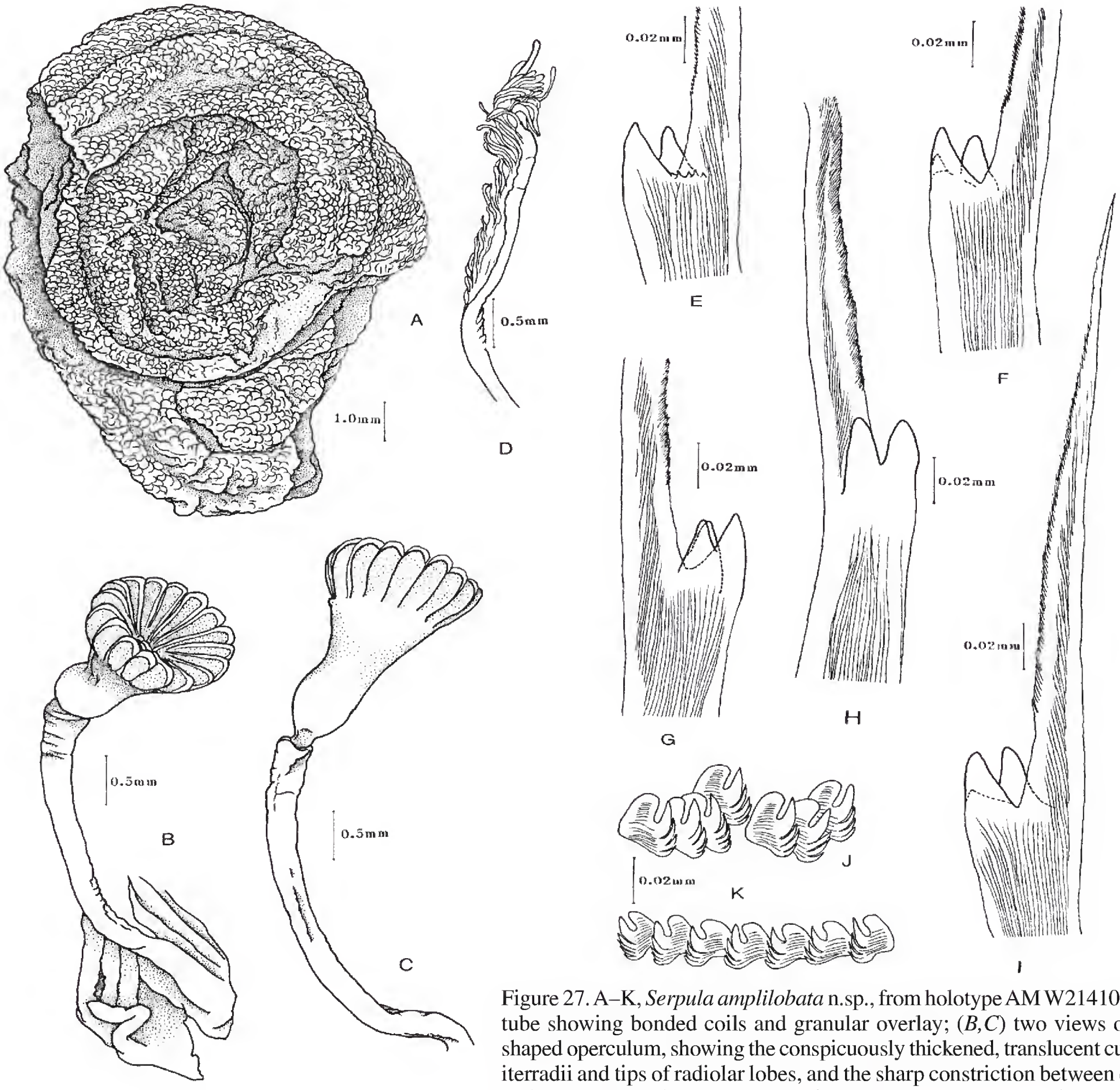

Figure 27. A–K, *Serpula amplilobata* n.sp., from holotype AM W21410: (*A*) coiled tube showing bonded coils and granular overlay; (*B,C*) two views of the bell-shaped operculum, showing the conspicuously thickened, translucent cuticle along iterradii and tips of radiolar lobes, and the sharp constriction between operculum and peduncle; B also shows the rudimentary operculum; (*D*) a branchial radiole; (*E–I*) bayonet-shaped special collar chaetae; note the short unserrated notch; (*J*) thoracic uncini; (*K*) anterior abdominal uncini.

Gap separating anterior abdominal tori (Fig. 28H): widest between first pair, then gradually becoming narrower till about 10th pair, where it is narrowest, after which it remains nearly the same for the next dozen segments or so, and then widens slightly in most of the abdomen.

Remarks. As stated by ten Hove (1994) *Serpula magna* Straughan 1967 is *Serpula jukesii* Baird, 1865. Straughan (1967a,b) was dealing with more than one species of *Serpula* under her descriptions of *S. vermicularis*. Straughan's (1967a) figure 3a is not of *S. vermicularis*. The very high number of opercular radii (80) suggests that some of them were possibly *S. jukesii*.

Serpula nudiradiata n.sp.

Figs 29G–L, 30A–I

Material examined. Kimberleys, Western Australia, HOLOTYPE AM W202942, reef south of Lucas Island, 15°16'S 124°29'E, 2 m, 24 Jul. 1988, st 102; coll. P.A. Hutchings.

Description

Measurements. Total length of worm 21.9 mm; width of thorax 1.7 mm; length of operculum and peduncle 5.7 mm; length of operculum 2.0 mm; diameter of operculum 2.0 mm; length of abdomen 15.7 mm. Abdominal segments number about 122, with capillaries starting from about segment 95.

Tube. White, quadrilateral in cross-section. A granular overlay present in anterior part of tube. Three longitudinal ridges faintly recognizable anteriorly along its crest (Fig. 29G); small irregular depressions present between ridges; an

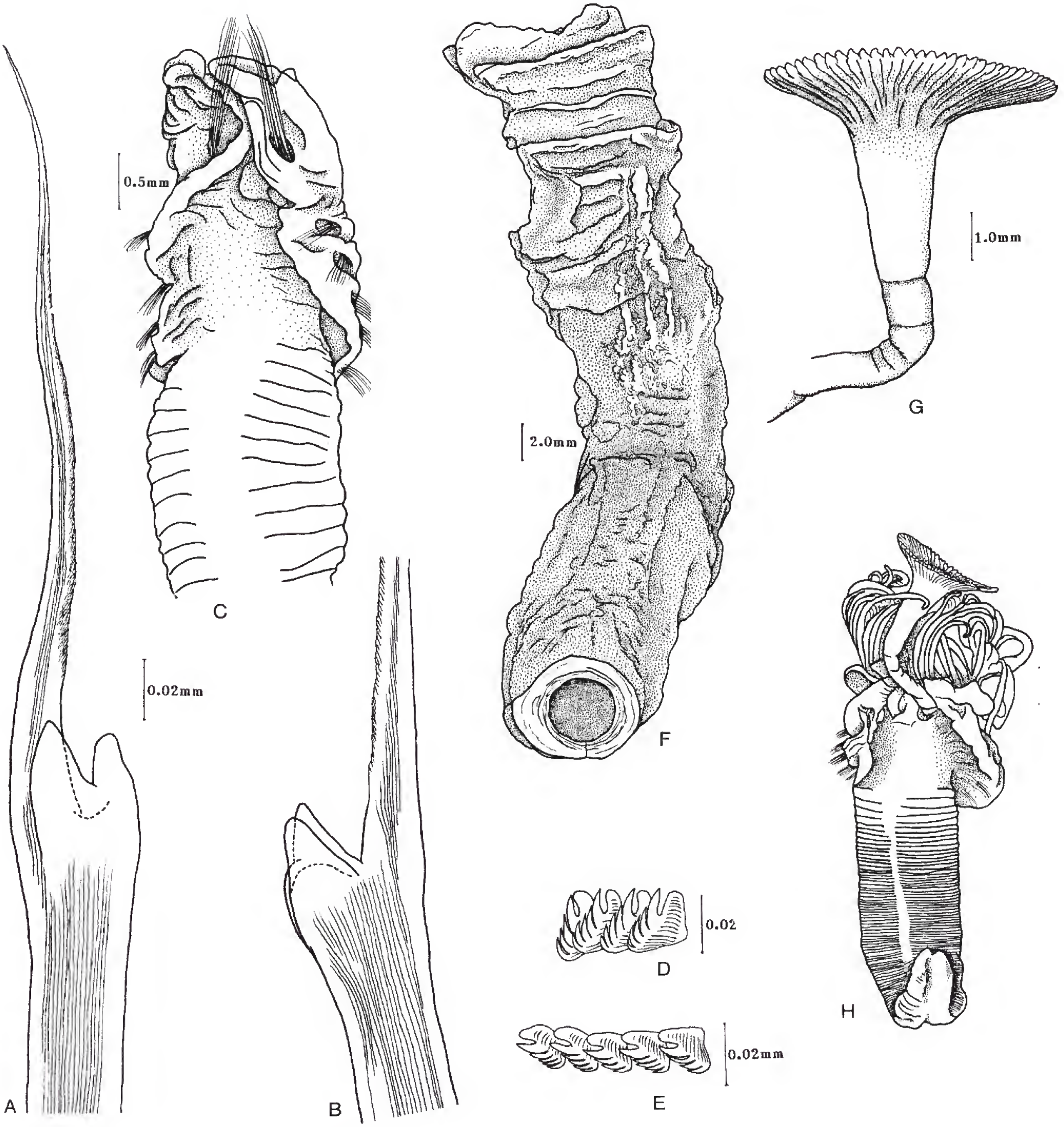

Figure 28. A–E, *Serpula amplilobata* n.sp., from holotype AM W21410: (*A,B*) bayonet-shaped collar chaetae; (*C*) arrangement of anterior abdominal uncinal tori; (*D*) thoracic uncini; (*E*) anterior abdominal uncini; F–H, *Serpula jukesii* Baird, 1865, from AM W21934: (*F*) tube; (*G*) lateral view of operculum; (*H*) arrangement of abdominal uncinal tori.

MLR and a LLR along either side of it clearly recognizable in posterior part of tube (Fig. 29G).

Worm. Distal part of operculum circular, followed by a funnel-shaped part, latter like an inverted cone decreasing in diameter noticeably and having a constriction between latter and a bulbous proximal part before it joins the peduncle (Fig. 29H,I). A sharp constriction present between bulbous part of operculum and the moderately thick peduncle (Fig. 29H,I). Opercular radii terminate in 42 rounded marginal lobes; their cuticle thin and translucent; tubercles absent (Fig. 29 I). Number of branchial radioles: 24 on each side, pinnule-free tips moderately long and slender; operculum on right, rudimentary operculum on left (Fig. 29H). Thoracic glands represented by a pair of openings on ventral side of thorax (Fig. 29K), with reddish pigmentation around them. Apron is present (Fig. 29K).

Chaetae. Eight bayonet-shaped special collar chaetae present in one of the fascicles examined. Each has a comparatively stout shaft, a conspicuously squarish boss which bears 2–6 triangular teeth, and a transverse row of small serrations, of variable length, either preceding them or at the angle between the boss and the blade (Figs 29L, 30A–E). An unserrated notch is absent (Figs 29L, 30A–E), even in older worn-out chaetae (Fig. 30B), a characteristic feature of present species.

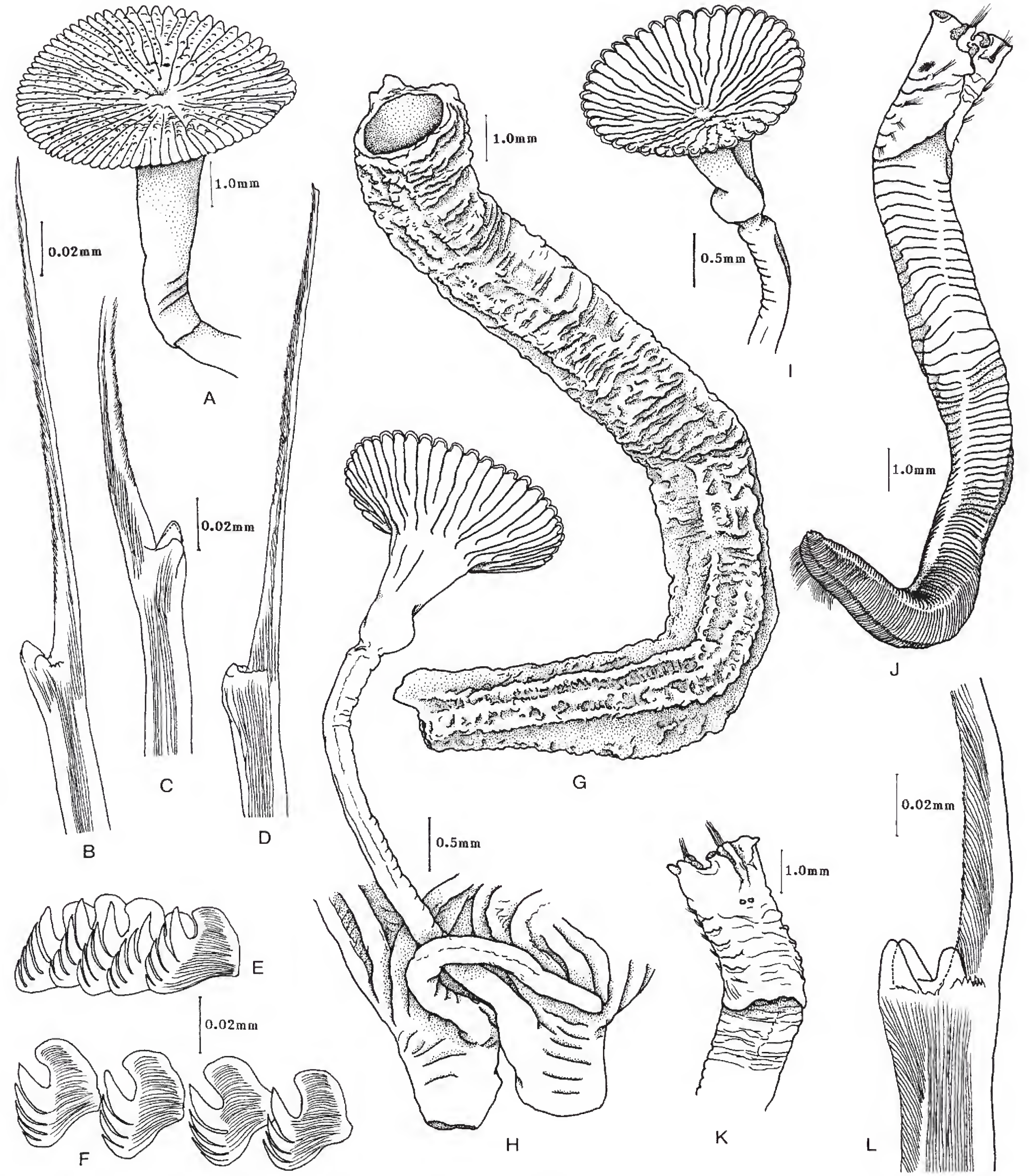

Figure 29. A–F, *Serpula jukesii* Baird, 1865 from AM 21934: (*A*) operculum; it lacks a bulbous proximal part, and its cuticle is thin; (*B–D*) bayonet collar chaetae; B,C, show the moderately long unserrated notch; D, an older chaeta in which the un-serrated notch is very long due to the original notch being worn out; (*E*) thoracic uncini; (*F*) anterior abdominal uncini. G–L, *Serpula nudiradiata* n.sp., from holotype, AM W202942: (*G*) tube; (*H*) operculum in lateral view, and rudimentary operculum; (*I*) anterolateral view of operculum; both H and I the thin cuticle, the proximal bulb-shaped part and distal funnel-shaped part, and a sharp constriction present between the opercular peduncle and the operculum; the operculum also has basal bulb, with a constriction between is also present between the proximal bulbous part and the distal funnel-shaped part; (*J*) dorsal view of abdomen showing the narrow gaps separating abdominal tori.; the tori almost meet from about the 9th/10th pairs to about the 16th/17th pairs and the gaps gradually increase again; (*K*) ventral view of thorax showing the 2 apertures for thoracic glands, and the apron; (*L*) bayonet-shaped collar chaeta, showing stout shaft, squarish boss, more or less triangular and blunt teeth, and lack of an un-serrated notch.

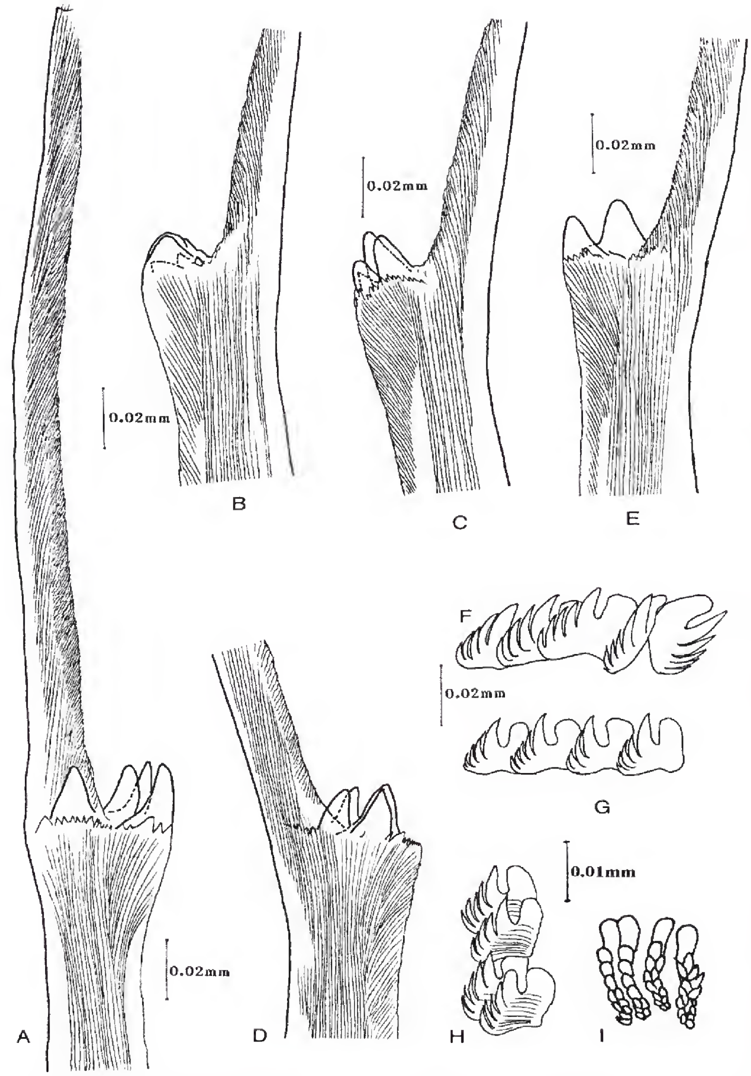

Figure 30. A–I, *Serpula nudiradiata* n.sp., from holotype, AM W202942: (*A–E*) bayonet-shaped collar chaetae showing variations in the number of teeth and serrations at the base of the blade, as well as absence of an un-serrated notch; (*F,H*) thoracic uncini; (*G*) anterior abdominal uncini; (*I*) posterior abdominal uncini.

Thoracic uncini saw-shaped, with 5 teeth in a single row, the 3 posterior ones are considerably smaller than the 2 anterior to them (Fig. 30F,H). Anterior abdominal uncini smaller, with 4 or 5 teeth in a single row, of which the posterior 3 or 4 are abruptly smaller than most anterior tooth and approximately equal size (Fig. 30G); posterior abdominal uncini rasp shaped (Fig. 30 I). Corresponding pairs of anterior abdominal uncinal tori separated dorsally by a very short gap; widest gap between first pair, then decreases quickly from second, very narrow from about 3rd to 9th; almost meet from about 10th to the 20th (Fig. 29J); then widens, with tori being comparatively close together in rest of abdomen.

Remarks. *Serpula nudiradiata* differs from *S. jukesii* in several respects. It lacks tubercles along the opercular radii, and possesses a sharp constriction between its peduncle and the operculum, a bulbous swelling in the proximal part of operculum, and a pair of apertures for the thoracic glands on the ventral side of the thorax. Its bayonet-shaped special collar chaetae are also different from those of *S. jukesii*: they lack an unserrated notch, and possess 2–6 teeth on the conspicuously squarish boss, and a transverse row of small serrations, which precede the larger teeth on the boss (Figs 29L, 30A–E).

Etymology. The specific name *nudiradiata* denotes one of the characters i.e., lack of tubercles along the radii of the operculum, which distinguishes it from certain other species, such as *S. jukesii*, that possess them.

?*Serpula* species

Fig. 31A–I

Material examined. Kimberleys, Western Australia, 1 specimen with tube and rudimentary operculum only, AM W21414, south side of Slate Island, 15°32'S 124°24'E, lower intertidal, rocks, 9 Jul. 1988, st 5; coll. P.A. Hutchings.

Description

Measurements. Length of worm, excluding missing operculum, c. 15.0 mm; width of thorax 1.0 mm; length of abdomen 8.6 mm. Number of abdominal segments about 73; but not clear where capillaries commence since they are mostly missing.

Tube. Tube trapezoidal in cross-section and consists of a posterior attached part and an anterior unattached part (Fig. 31A,B); its unattached portion characterized by a series of peristomes; dorsomedially, peristomes are directed anteriorly (Fig. 31A). Aperture of tube surrounded by a broad rounded anteriorly directed upper lip, separated by an indentation on each side from a ventrolateral lip; the latter two separated by a mid-ventral indentation (Fig. 31B). The dorsal lip may be partially subdivided into two by a faint indentation (Fig. 31B). The trilabiate condition, and even the partially subdivided dorsal lip, may be seen in peristomes along the tube.

Worm. Number of radioles 11 radioles plus rudimentary operculum on left; radioles missing on right, but base of opercular peduncle can be recognized. Light brown clusters of prostomial ocelli clusters present. Thorax has 7 chaetigers; apron present.

Chaetae. Special collar chaetae bayonet-shaped; either bear two conical to triangular teeth at the base of the blade, with a smaller tooth between them (Fig. 31D,E,G,H), or only two main teeth (Fig. 31C,D). Unserrated notch is moderately long, even in a newly formed chaeta from within fascicle (Fig. 31F,H); blade about 6 times as long as unserrated notch. Thoracic uncini: saw-shaped, with 7 teeth (Fig. 31H); anterior abdominal uncini similar, with 4 or 5 teeth (Fig. 31 I). Corresponding pairs of anterior abdominal tori almost meet along the mid-dorsal line of the abdomen.

Remarks. Unfortunately, the operculum is missing and it not possible to decide which genus among the Serpulinae *sensu stricto* it belongs to. *Spiraserpula* Regenhardt can be eliminated because of the lack of internal tube structures

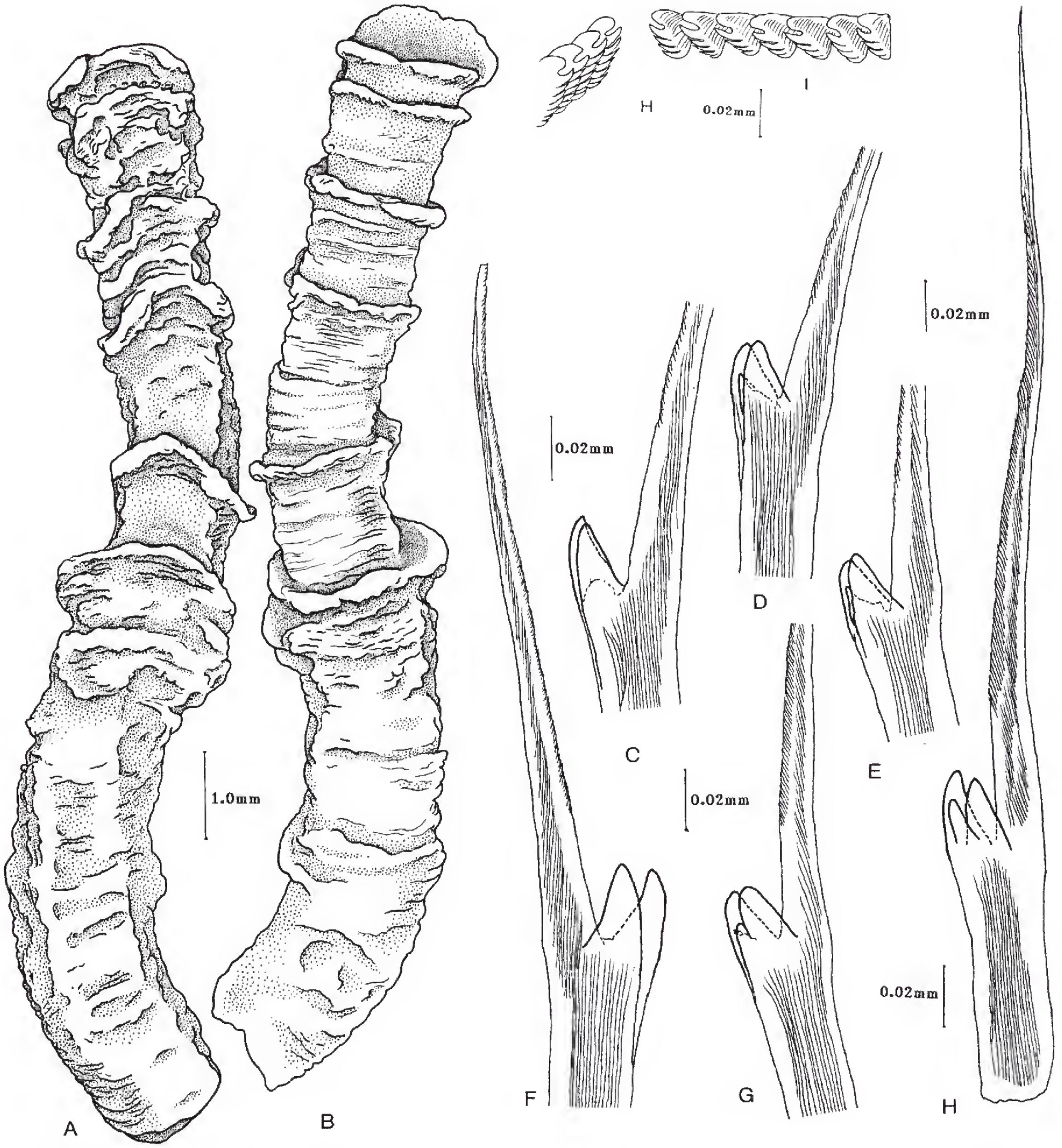

Figure 31. A–I, *Serpula* sp.? from AM W21414: (*A,B*) dorsal and ventral views of the tube; (*C–H*) bayonet-shaped special collar chaetae; (*F,H*) bayonet-shaped chaetae from deep within the collar fascicle showing a moderately long unserrated notch; (*H*) thoracic uncini; (*I*) anterior abdominal uncini.

and the presence of an apron. Its tube is quite unlike those of known species of *Serpula, Crucigera* or *Hydroides* from the Indo-West Pacific, although it could belong to any one of them, although the peristomes along the tube suggest that could be a species of *Serpula*. Future studies based on additional material would help to determine this very interesting species

Serpula watsoni Willey, 1905

Figs 32A–N, 33A–N

Serpula watsoni Willey, 1905: 317, pl. VII, fig. 187 and pl. VIII, fig. 6.

Serpula watsoni Willey.—Straughan (1967a: 207, fig. 3b), Imajima & ten Hove (1986: 2), Sun & Yang (2001: 194, fig. 6G–M).

Material examined. Kimberleys, Western Australia: 1 specimen, AM W202694, south west corner of Lucas Island, 15°13'S 124°31'E, on dead *Pecten* shell, 30 m, 24 Jul. 1988, st 101; 2 specimens, AM W21408, Lafontane Island, 14°10'S 125°47'E, 15 m, 19 Jul. 1988, st 68. One tiny juvenile specimen, with part of tube, AM W221446, reef north west of Buffon Island,14°55'S 124°41'E, 20 m, 23 Jul. 1988, st 85; all coll. by P.A. Hutchings.

Description

Measurements. Specimen from AM W202694 has a complete tube: 43.0 mm long, external width 2.7 mm. Total length of worm is 6.8 mm, thoracic width 1.0 mm; abdominal length 5.8 mm. A specimen from AM W21408 has a thoracic width of 2.0 mm; longest operculum and peduncle 4.2 mm, operculum itself 2.0 mm long in two specimens; largest opercular diameter 1.7 mm. Juvenile specimen: width of tube 0.5 mm; total length of worm 2.1 mm; width of thorax 0. 4

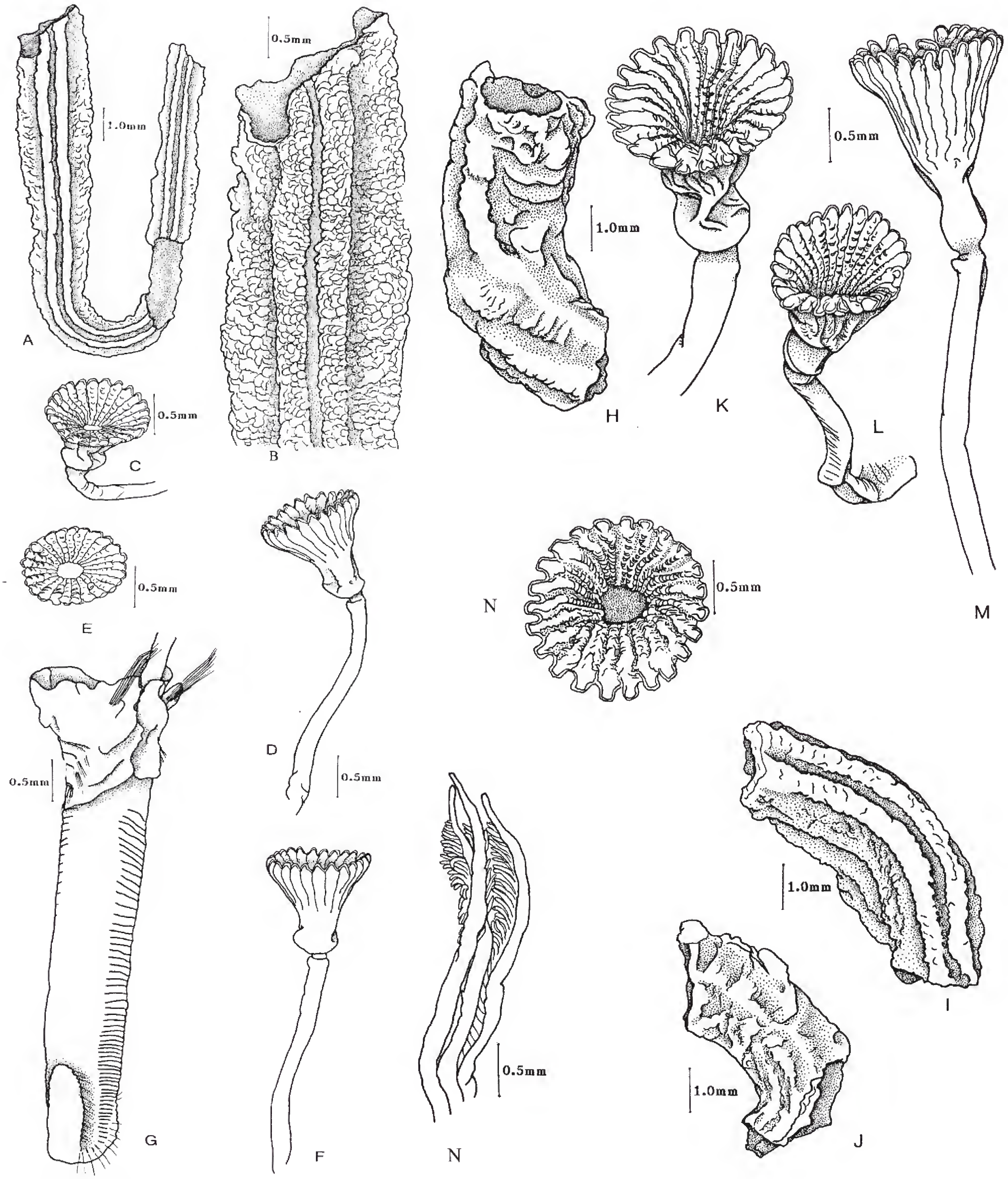

Figure 32. A–O, *Serpula watsoni* Willey, 1905. A–G, a juvenile specimen from AM W202964. (*A*) tube; (*B*) part of tube magnified to show granular overlay and pair of longitudinal ridges situated close together with a deep groove between them, and another groove just lateral to each of them leaving a broad, somewhat rounded flank which gradually slopes outwards; (*C–F*) various views of the operculum showing the triangular lobes ending distally in more or less rounded to squarish tips, presence of tubercles along the radii, and a hollow cavity extending into the bulbous part of the operculum (C,E); (*G*) dorsal view of the abdomen showing a very wide gap separating the uncinal tori of the two sides. H–N, from AM W21408 (*E–G*) tube fragments; (*K–N*) various views of an adult operculum; (*L*) pinnule-free tips of radioles.

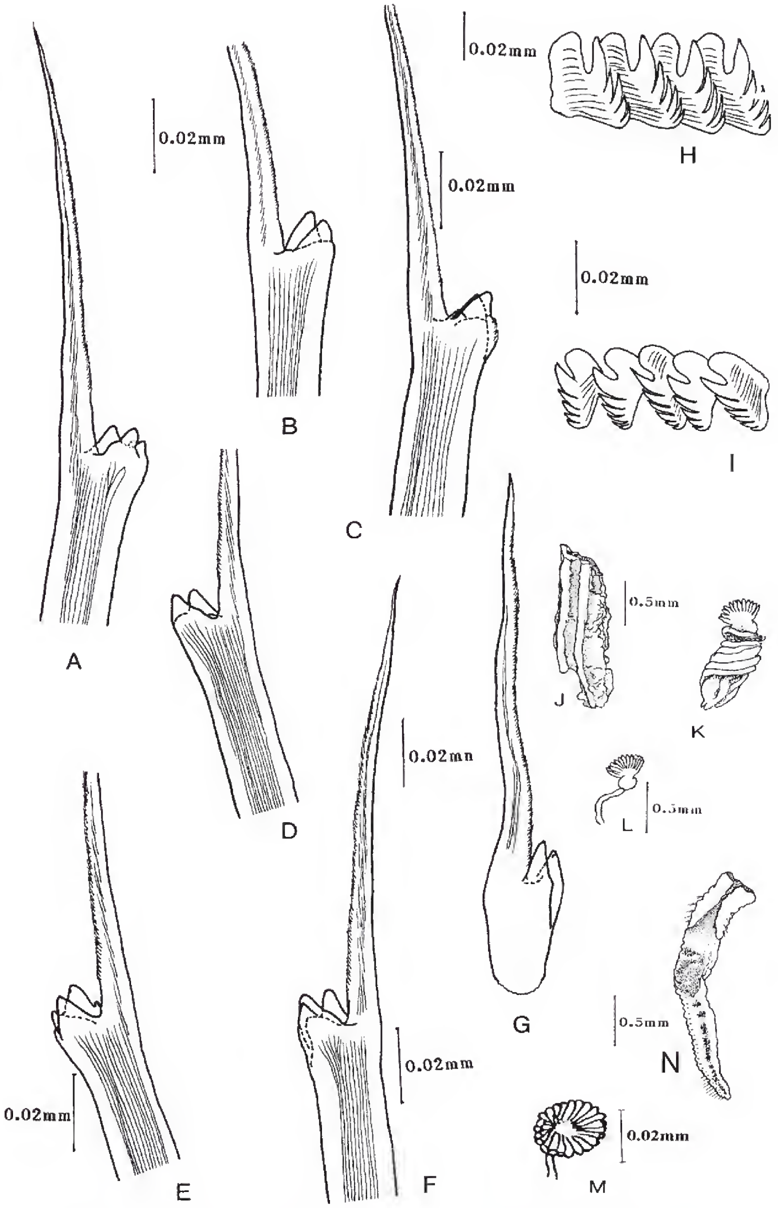

Figure 33. A–N, *Serpula watsoni* Willey, 1905. A–I, from AM W21408; J–N, juvenile specimen from AM W21446. (*A–G*) bayonet-shaped special collar chaetae; (*H*) thoracic uncini, (*I*) anterior abdominal uncini; (*J*) tube; (*K*) operculum and radioles separated body of worm (*N*); (*L,M*) two views of operculum; dorsal view of worm.

mm; length of operculum and peduncle 1.5 mm, length of operculum 0.5 mm, and length of abdomen 1.6 mm.

Tube. White, trapezoidal in cross-section in first specimen, with two uniformly developed smooth longitudinal ridges along its crest, with a narrow, comparatively deep longitudinal groove running between them (Figs 32A,B, 33J). Along the lateral base of each longitudinal ridge is a lateral longitudinal groove that tucks underneath the ridge and demarcates it from the rounded flank of that side. Lateral edge along each flank decreases in thickness laterally. A translucent granular overlay is present (Fig. 32B). Tube similar in second specimen, with regard to longitudinal ridges and grooves, but the median longitudinal groove is not deep where parts of the tube appear to have grown unattached to the substratum (Fig. 32H,J); the typical form, however, is recognizable in the more horizontal part (Fig. 32I).

Juvenile tube white, shiny on inside; two smooth longitudinal ridges present along its crest, with a longitudinal groove between them; latter wide compared to size of tube (Fig. 33J); a faint granular overlay discernible along its lateral borders; internal tube structures absent.

Worm. Operculum bell-shaped (Fig. 32C–F,K–M); its proximal part swollen and bulbous before it joins the peduncle; constriction between operculum and peduncle sharp (Fig. 32D,F,K,M). Numbers of marginal opercular lobes in the three specimens examined: 29, 23 and 25; triangular with blunt tips in juvenile specimen (Fig. 32C–F); rounded to squarish in the others (Fig. 32K–M); cuticle thin and translucent in younger specimens (Fig. 32C–F); somewhat thicker in older specimens (Fig. 32K–N). As seen in figures mentioned, tubercles present along the radii, more prominent in older specimens. Funnel-shaped opening of the distal part of the operculum leads into a hollowed cavity with its bulbous proximal part (Figs 32D,E,K,N). Highest number of radioles amongst the three specimens, 20 plus operculum on left and 18 plus rudimentary operculum on right; smallest number 12 plus operculum on right, and radiolar crown missing on left; pinnule-free tips longer and thicker than pinnules (Fig. 32N). Prostomial ocelli and apertures for thoracic glands absent; apron present. Number of abdominal segments in a complete specimen about 79; capillaries start from about segment 45.

Juvenile worm: operculum bell-shaped (Fig. 33K,M), bears 23 marginal lobes; latter nearly triangular, with smooth tips; uncertain whether a hollow is present within operculum in the early juvenile condition (Fig. 33M). Radioles number 4 on each side; a short filamentous rudimentary operculum on left, operculum on right; pinnule-free tips short and slender. Number of thoracic chaetigers 7; an apron is present. Number of abdominal segments 32 abdominal segments, capillaries start from the twenty-third.

Chaetae. Bayonet-shaped special collar chaetae (Fig. 33A–G) usually possess two, sometimes three teeth at base of blade; in fully formed bayonets, boss as well teeth directed away from blade (Fig. 33A–F); in newly formed bayonets from within collar fascicle, teeth directed parallel to or slightly towards the blade (Fig. 33G). Unserrated notch short to moderately long in the older bayonets (Fig. 33A,E), yet to be developed and not evident those within collar fascicle (Fig. 33G);. Thoracic uncini saw-shaped (Fig. 33H) and bear 5 or 6 teeth; anterior abdominal uncini similar (Fig. 33H) with a similar number of teeth. Abdominal neuropodia with about 13 flattened trumpet-shaped chaetae in each chaetal fascicle. Corresponding pairs of anterior abdominal uncinal tori are lateral separated dorsally by a very wide gap (Fig. 32G).

The juvenile possesses 4 bayonet-shaped special collar chaetae per fascicle, each bearing 2–4 teeth at base of blade, of which 2 may be larger than the rest; similar to the number described for adult specimens. Thoracic uncini bear 5 or 6 teeth in a single row.

Remarks. *Serpula watsoni* Willey is similar to *S. amplilobata* and *Serpula nudiradiata* described earlier in that the proximal part of its operculum is bulbous and a sharp constriction occurs between the operculum and the peduncle. However, unlike in both the latter species, *S. watsoni* possesses a cavity extending from the funnel-shaped distal part to into the bulbous proximal part of the operculum. *Serpula watsoni* possesses tubercles along its radii, whereas they are absent in both *S. nudiradiata* and *S. amplilobata*. The spirally coiled tube with mutually bonded coils of *S. amplilobata* (Fig. 27A) distinguishes it from tube of *Serpula watsoni* (Figs 32A,B,H–J). For differences between their collar chaetae see relevant descriptions. Straughan's figure (1967a, fig. 3b) of *S. watsoni* does not show the bulbous proximal part of the operculum that observed by Willey (1905: pl. VIII, fig. 6) and in the present account (Fig. 32C,D,F,K,M). Straughan's figure (1967a, fig. 3a) of *S. vermicularis* appears to be that of a juvenile *S. watsoni* (*vide* Fig. 33J–M in the present account).

The tube of the juvenile specimen, with its two longitudinal ridges along its crest (Fig. 33J), is similar to that of older specimens of *S. watsoni* (Fig. 32A,B,I). Bayonet-shape collar chaetae are also similar. It is uncertain whether a hollow is present in the bulbous proximal part of the operculum in the early juvenile condition.

Genus *Spiraserpula* Regenhardt, 1961

Type species. *Spiraserpula spiraserpula* Regenhardt, 1961.

Diagnosis. Operculum chitinous; funnel-shaped, usually bearing dichotomous radii ending in marginal lobes, only a few or lacking in certain species; inserted in position of second branchial radiole; peduncle non-pinnulate; inter-radiolar membranes absent. Number of thoracic chaetigers: seven or more. Apron: absent. Special collar chaetae usually bayonet shaped, bearing two to a number of teeth on boss. Most anterior uncinal tooth: larger than the rest. Distal ends of abdominal neurochaetae shaped like asymmetrically 'flattened trumpets', with one side longer than other, and bear numerous serrations or denticulations. Apron absent, as an adaptation to presence of internal tube structures. Tube: internal tube structures present.

Remarks. The genus *Spiraserpula* was first known from Cretaceous fossils (*vide* Regenhardt [1961], Jäger [1983] and Pillai [1993]). For descriptions of the type species *S. spiraserpula* Regenhardt 1961, *S. versipellis* Regenhardt 1961 and other fossil species of *Spiraserpula*, see Regenhardt (1961: 41–44) and Pillai (1993: 71–82). For 18 extant species of *Spiraserpula* see Pillai & ten Hove (1994) and ten Hove & Kupriyanova (2009).

Spiraserpula snellii
Pillai and ten Hove, 1994

Figs 34A–E, 35A–J

Spiraserpula snellii Pillai & ten Hove, 1994: 39–104.
Spiraserpula sp.—ten Hove (1994: 112).

Material examined. Kimberleys, Western Australia,1 specimen, AM W21475, south west corner of Lucas Island, 15°13'S 124°31'E, 30 m, on a dead oyster shell, 24 Jul. 1988, st 101; coll. P.A. Hutchings.

Description

Measurements. Maximum external diameter of tube 1.5 mm in places, elsewhere about 1.2 mm. Worm (radioles missing): length of thorax and abdomen 18.0 mm, width of thorax 0.5 mm; length of abdomen 16.8 mm.

Tube. Has an overall brownish mustard colour, with a lateral longitudinal pigment band on each side and a less distinct and narrower median longitudinal band. In addition to the mustard colour, a pinkish tinge present dorsally. A granular overlay is present (Fig. 34A,B), granules being larger along the lateral borders. Forwardly directed peristomes may be present (Fig. 34A,E). Internal tube structures present, consisting only of a ventral longitudinal ridge; it is somewhat T-shaped in cross-section posteriorly (Fig. 34C). More anteriorly, as the ventral ridge decreases in height, it develops a shallow longitudinal groove, which gives it a somewhat Y-shaped appearance (Fig. 34E) and, still more anteriorly, becomes wedge-shaped and skewed (Fig. 34D), then tapers to a simple low ridge.

Worm. Thorax has a pair of brownish-black clusters of ocelli (Fig. 35A,C); 7 chaetigers; lacks an apron; possesses a deep ventral abdominal longitudinal groove (Fig. 35A–D) to accommodate ventral internal tube structures (Fig. 34C–E).

Chaetae. Special collar chaetae bayonet-shaped, possess a long serrated blade and several teeth on the basal boss, but lack an unserrated notch (Fig. 35E–G). Thoracic uncini saw-shaped (Fig. 35H), with 4 or 5 teeth in a single row; anterior and mid-abdominal uncini different in shape, but possess a similar number of teeth (Fig. 35I,J, respectively); posterior abdominal uncini rasp-shaped. Anterior and middle abdominal segments possess 2 or 3 flattened trumpet-shaped chaetae per fascicle. Anterior abdominal tori are short and laterally located up to about the eleventh chaetiger, then gradually become dorsolateral and longer, after which they almost meet mid-dorsally, being separated by very short distance, from about the twenty-fourth pair onwards (Fig. 35A–D).

Remarks. The single specimen available is significantly larger than those described by Pillai and ten Hove (1994) and provides additional data on intra-specific size and meristic variability. In the material described in 1994, external tube diameter did not exceed 0.6 mm; maximum total length of worms was about 12.5 mm and maximum abdominal length 11.2 mm. The number of thoracic chaetigers in the present specimen, 7/7, falls within the range encountered in 1994. However, its thoracic membranes extend further backwards, to thoracic chaetiger 6/6. Maximum number of abdominal segments encountered in the 1994 specimens was only 48 for an abdominal length of 11.2 mm. It is very much higher in the Kimberleys specimens, 158 for an abdominal length of 16.8 mm.

Subfamily Spirobranchinae Uchida, 1978

Type genus. *Spirobranchus* Blainville, 1817

Type species. *Spirobranchus giganteus* (Pallas, 1766) (= *Serpula gigantea* Pallas, 1766)

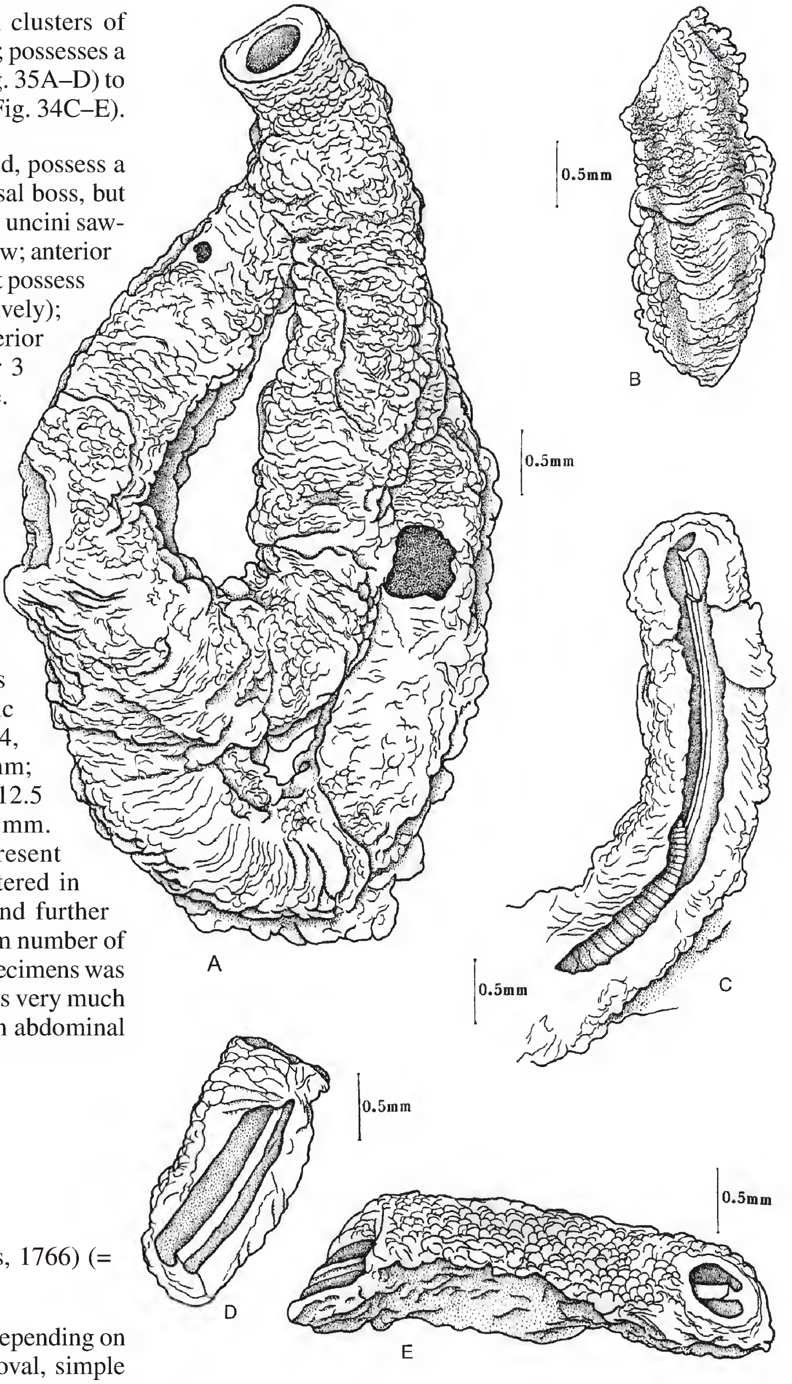

Figure 34. A–E, *Spiraserpula snellii* Pillai & ten Hove, 1994, from AM W21475. (*A,B*) external view of tube; (*C–E*) showing internal tube structures.

Diagnosis (emended): Operculum calcareous; depending on the taxon, opercular plate may be circular or oval, simple and flat or corrugated, concave, convex or conical, with or without branched spiny processes arising from it, or may consist of stacked disks; peduncle winged; wings may or may not be fringed. Operculum inserted in position of second dorsal radiole of left side, extremely rarely on the right; rudimentary operculum absent on opposite side. Branchial radioles may be arranged in a circle or a spiral, or may be in a circle in juveniles and spiral in adults. Inter-radiolar membranes present; may or may not be fringed. Thoracic membranes present; apron present. Thorax consists of seven chaetigers. Depending on the taxon, collar chaetal fascicles may be present in both juveniles and adults, or may be reduced or absent in adults but present in some juveniles. Special collar chaetae: may be bayonet-shaped, with a squarish serrated boss; latter may be reduced to various extents, even completely, when they may be similar to the simple bladed chaetae hat accompany them; distal part of chaetal shaft preceding boss serrated in both well-developed and reduced bayonet-shaped special collar chaetae; an un-serrated notch absent between the serrated boss and blade. Serrations of blade may be fine, short and hair-like in some taxa, longer and wavy in others. Thoracic uncini saw-shaped; their anterior process gouged. Abdominal tori lateral; uncini similar to those of the thorax, usually with fewer teeth; posterior uncini may be rasp-shaped. Abdominal neurochaetae have flattened trumpet-shaped ends, with

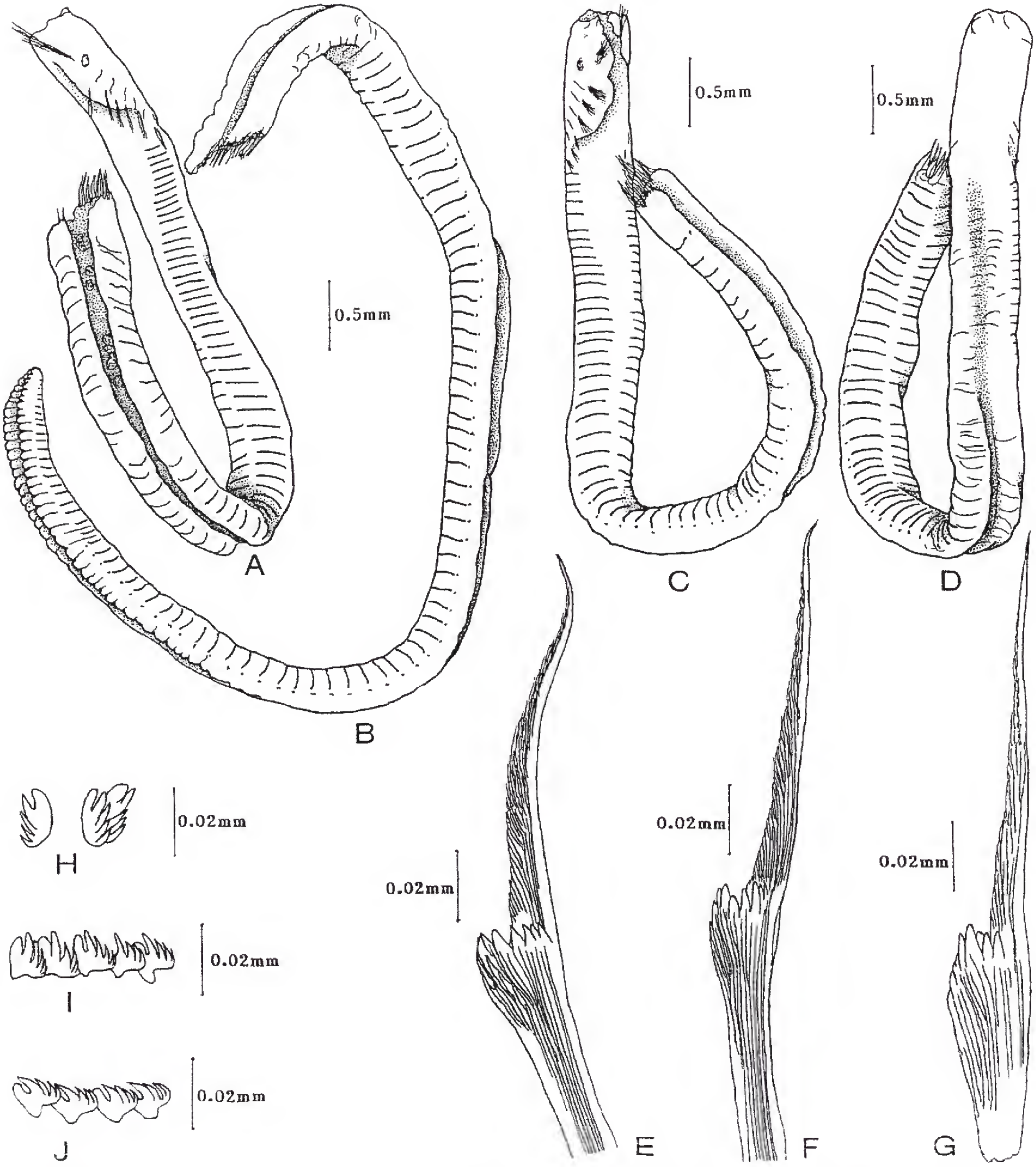

Figure 35. A–J, *Spiraserpula snellii* Pillai & ten Hove, 1994, AM W21475 (continued), (*A,B*) whole worm in two parts [A, shows ventral groove along the abdomen, which is applied along the ventral longitudinal internal tube structure]; (*C,D*) two further views of anterior part of worm; (*E–G*) bayonet-shaped special collar chaetae; (*H*) thoracic uncini; (*I*) anterior abdominal uncini; (*J*) posterior abdominal uncini.

one side drawn into a long tapering process; possess long shafts that protrude conspicuously from the abdominal wall; although may not be evident in adults of certain taxa, they are present in juveniles.

Remarks. Hartmann-Schröder (1996: 565) uses the Subfamily uses Uchida's Spirobranchinae, including the genera *Pomatoceros* and *Placostegus* under it. However, the subfamily consists of the single genus *Spirobranchus* (Blainville, 1818) in the present paper, with the genera *Pomatoceros* Philippi, 1844, and *Pomatoleios* Pixell, 1913, synonymized with it. Uchida (1978) included, among others, the genera *Spirobranchus, Pomatoceros, Pomatoleios* and *Ditrupa*, under it. However, Regenhardt (1961) erected the new subfamily Ditrupinae with type genus *Ditrupa* Berkeley, 1835, and *Ditrupa arietina* (Müller, 1766) as type species.

The above emended diagnosis of *Spirobranchus* takes into account the side on which the operculum occurs. It has been reported as being always a modification of the second radiole of the left side in almost all its species. It would, however, be useful to note that, out of a hundred of the Mediterranean *Pomatostegus polytrema* (Philippi, 1844) (= *Spirobranchus polytrema* in the present paper) examined by Zibrowius (1964), only one had the operculum arising on the right. According to Imajima and ten Hove (1984) it may arise from the left or right in *S. decoratus* Imajima, 1982.

Although this difficult genus has received much attention in recent decades, the taxonomy of its species is yet to be satisfactorily resolved. The Kimberleys collection includes species of *Spirobranchus* that, due to lack of reliable characters for separating what appear to be more than a single species, have recently been referred to in publications as belonging to *Spirobranchus* "species groups" or "species complexes", which need to be resolved in due course. With this end in view, the Kimberleys collections of *Spirobranchus* were compared with other Indo-West Pacific collections belonging to the genus available in the Natural History Museum, London, and the Australian Museum, Sydney. Although the scope of this study is not intended to be a revision of *Spirobranchus* and its species complexes, it has yielded interesting results, which are presented below.

Ten Hove (1970a), in a revision of the genus *Spirobranchus* Blainville, 1818, recognizes the following. Firstly, that there are two main groups of species: those in which the branchial radioles are spirally arranged and the opercular wings are fringeless, as in *S. giganteus*, and those in which they are arranged in a circle and the opercular wings are fringed, as in *S. tetraceros*. Secondly, that. *Spirobranchus giganteus giganteus* (Pallas, 1766) occurs in the tropical and subtropical coasts of America, while *S. giganteus corniculatus* (Grube, 1862), *sensu* ten Hove 1970, occurs from the Red Sea to the central Pacific. Thirdly, that *S. tetraceros* (Schmarda, 1861), *S. giganteus giganteus* (Pallas, 1766), *S. polycerus* (Schmarda, 1861) and *S. polycerus* (Schmarda, 1861) var. *augeneri* Hove 1970, are valid taxa from the Caribbean. Fourthly, that there are seven other valid taxa belonging to the genus *Spirobranchus* worldwide, namely, *S. eitzeni* Augener (1918), *S. giganteus* (Pallas, 1766) Blainville, 1818; *S. latiscapus* (Marenzeller, 1885) (including *S. maldivensis* Pixell, 1913), *S. lima, S. polycerus* (Schmarda, 1861) Mörch, 1863, *S. polytrema* and *S. tetraceros* (Schmarda, 1861).

Furthermore, ten Hove (1994) recognizes *S. paumotanus* (Chamberlin, 1919), which he earlier (1970) synonymized with *S. giganteus*, and the following species from the Indo-West Pacific: *S. coronatus* Straughan, 1967, *S. corrugatus* Straughan, 1967 and *S. gardineri* Pixell, 1913, while expressing the possibility that the latter may consist of two species. Ten Hove & Nishi (1996), while providing a very good re-description of *Spirobranchus corrugatus* Straughan, 1967, show that it has an Indo-West Pacific distribution, although originally described from Australia.

According to Smith (1985, unpublished thesis) what had been identified in the past as *S. giganteus* and *S. tetraceros* are each a group of closely related species, the limits of which are as yet unclear, and arrives at the following conclusions. 1. Tube colour, besides its form need to be given more importance than in the past. 2. There are three main *species complexes* in the Australian material studied by him, namely, those of *S. giganteus, S. tetraceros* and *S. latiscapus*. 3. The *Spirobranchus giganteus* (Pallas, 1766)-*complex* can be assigned to four species, and that the *Spirobranchus tetraceros* (Schmarda, 1861) complex can be assigned to three species. 4. *Spirobranchus decoratus* Imajima, 1982 and *S. gardineri* Pixell, 1913 are valid taxa, with two variant types of the latter. Fifthly, that *Spirobranchus giganteus giganteus*, and *S. polycerus* among the Caribbean species identified by ten Hove (1970), the seven species worldwide listed by the latter, and *S. spinosus* Moore 1923 from the Californian region are valid taxa.

Frank and ten Hove (1992) and ten Hove (1994) agree with Smith (1985), and believe that the *Spirobranchus giganteus* and *S. tetraceros* categories are in need of further revision. This includes species that had been incorrectly synonymized with others by ten Hove (1970). Under the *Spirobranchus tetraceros*-complex, for instance, ten Hove (1994: 113) states: "in 1970, I united various nominal taxa from circumtropical origin in a single species: *S. tetraceros*. Nowadays I realize that this has been an oversimplification, the taxon *tetraceros* probably contains a number of species… "

An important character pointed out by ten Hove (1994) between the *Spirobranchus giganteus* and *S. tetraceros* categories relates to the opercular plate. It is oval, and arises obliquely from the peduncle in the former, whereas it is circular and arises at right angles to the peduncle in the latter. Moreover, the arrangement of the branchial radioles is whorled in the *Spirobranchus giganteus* category but circular in *S. tetraceros* category, Ten Hove (1994) also refers to his earlier (1970) *S. giganteus corniculatus* complex as the *S. corniculatus* complex.

For a recent view on this see Kupriyanova *et al.* (2001: 74–75). The present study shows that not only certain "species complexes" of the genus *Spirobranchus* described in recent years consist of more than one species, but also that certain species previously synonymized with others are distinct species.

Spirobranchus is mainly a tropical to sub-tropical genus. However, its distribution will now extend to temperate waters with, for example, *Spirobranchus triqueter* (Philippi, 1844) (= *Pomatoceros triqueter*) in the Mediterranean, Northwest Atlantic and North Sea, to the Tasmanian Sea from where a new species *Spirobranchus tenhovi*, is described below.

Synonymy of the genera *Spirobranchus, Pomatoceros* and *Pomatoleios*

Zibrowius (1968: 161) discusses the close similarities between *Pomatoceros, Spirobranchus*, and *Pomatoleios* and points out the following: the only difference between them is in their collar chaetae, which are reduced or sometimes even absent in *Pomatoceros*. There is no reason to retain the genus *Pomatoleios*, based solely on the absence of collar chaetae, since there is a tendency towards their reduction and disappearance. Even if there are populations of *Pomatoleios* in which all the individuals lack collar chaetae there is no justification for retaining this genus. The tendency towards reduction of collar chaetae is equally present in the genus *Spirobranchus*, as exemplified by *S. eitzeni* Augener 1918. Special collar chaetae occasionally are absent in *Pomatoceros* and *Spirobranchus*, and present in some juvenile *Pomatoleios*. The distinction between hooded chaetae and "*Spirobranchus*-chaetae" sometimes is very hard to make. However, a (needed) revision of the complex of genera falls outside the scope of this paper."

The operculum in all three genera is a calcareous plate at the end of a winged peduncle. In *Spirobranchus*, it may lack processes, as in *S. maldivensis* Pixell 1913, or may bear processes, as in its various species, including "complexes". In *Pomatoceros triqueter* (Linnaeus, 1767), the opercular plate bears processes similar to those of species of *Spirobranchus* or may be devoid of processes, as in *S. maldivensis* (Fig. 52C–E). As remarked earlier, the shape of the opercular plate is oval in the *S. giganteus* and *corniculatus* category, but circular in

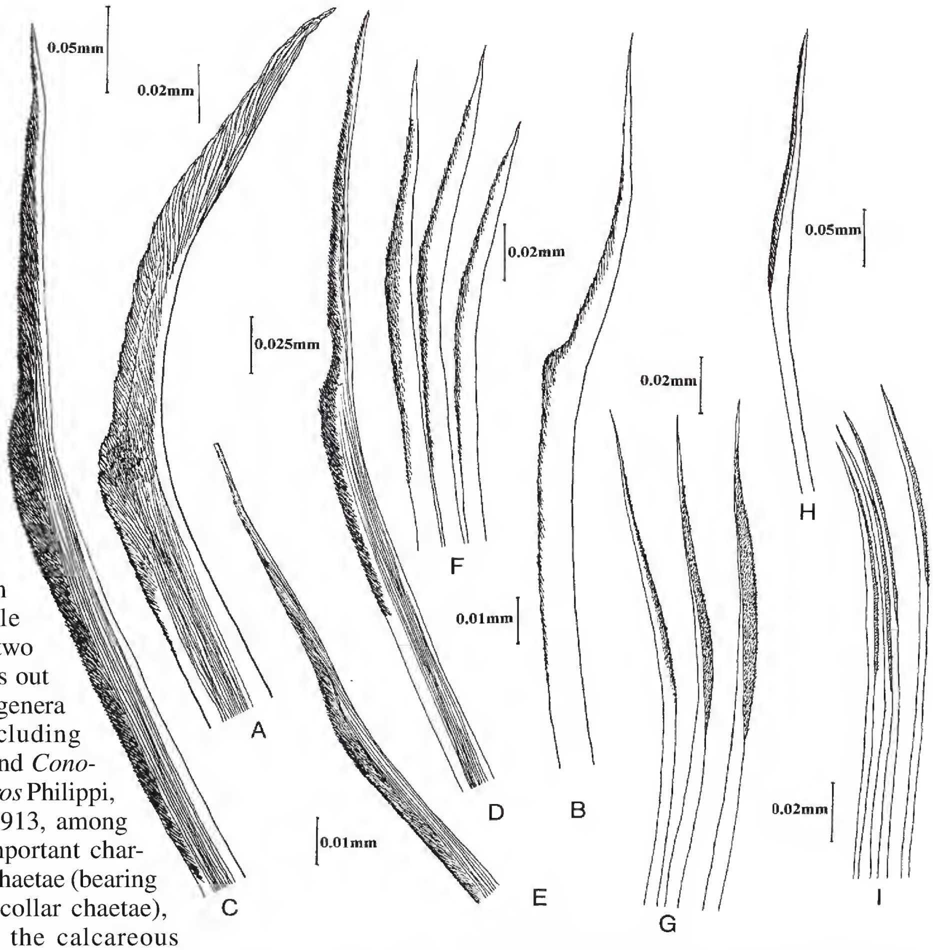

Figure 36. A–I, special collar chaetae of some species of *Spirobranchus* showing a complete range in form from the "*Spirobranchus*-type" with a squarish boss to those lacking a boss and being capillary-like as in *Pomatoceros triqueter*. (*A*) *S. corniculatus* Grube, 1862. (*B*) *S. maldivensis* Pixell, 1913. (*C*) *S. zelandicus* n.sp. (*D*) *S. murrayi* n.sp. (*E*) *S. tenhovi* n.sp. (*F*) *S.* sp. 3 (*G*) *S. zibrowii* n.sp. (*H*) *S. (= Pomatoleios) kraussii* (Baird, 1864). (*I*) *S. (= Pomatoceros) triqueter* (Linnaeus, 1767).

the *tetraceros* category. In both *Pomatoceros* and Zibrowius (1968) further states that if there are species having collar chaetae that are intermediate between the bayonet-shaped chaetae with a squarish boss in *Spirobranchus* and the simple chaetae of *Pomatoceros*, then the two genera should be united. He lists out similarities among the nominal genera *Spirobranchus* Blainville (including *Pomatoceropsis* Gravier, 1905 and *Conopomatus* Pillai, 1960), *Pomatoceros* Philippi, 1844 and *Pomatoleios* Pixell, 1913, among others, with regard to many important characters. They include the uncini, chaetae (bearing in mind the discussion on the collar chaetae), winged opercular peduncles, the calcareous opercular plates, possession of an apron, and the characteristic blue or violet body pigmentation, which is present in *Pomatoceros, Pomatoleios* and *Spirobranchus*. He concludes that they form a natural group and that, eventually, need to be reclassified more closely.

Ten Hove & Nishi (1996) state that "the differences between the nominal genera *Pomatoceros, Pomatoleios* and *Spirobranchus* are very small (if indeed existing), mainly lying in the collar chaetae. Absent in *Pomatoleios*, hooded (limbate) in *Pomatoceros* and bayonet-like with numerous hair-like teeth in the basal boss in *Spirobranchus*."

The three genera cannot also be satisfactorily separated on the basis that special collar chaetae in *Spirobranchus* are bayonet-shaped and possess a squarish boss, while those in *Pomatoceros* are capillary-like or capillaries, and that they are absent in *Pomatoleios*. It will be seen from descriptions of species of *Spirobranchus* that follow, that there is, in the various taxa, a complete range of special collar chaetae, from those in which the boss is prominently squarish to those in which it is reduced to various extents, even to capillaries. Among them is the new species *Spirobranchus zibrowii*, in which the special collar chaetae, like those of *Pomatoceros*, do not possess a recognizable boss, but are capillaries. In *Pomatoceros*, the reduction of the basal boss of collar chaetae is complete, making them capillaries, except for a very narrow blade that is discernible under high power magnification. In the light of observations of this character in the various species studied below (Fig. 36), it is impossible to separate the nominal genus *Pomatoceros* from *Spirobranchus*.

Pixell (1913) erected the genus *Pomatoleios*, consisting of the single known species, *Pomatoleios kraussii* (Baird, 1864), and distinguishing it from *Spirobranchus* on the basis that the former lacks collar chaetae while the latter possesses them. However, it had been shown by Zibrowius (1968), ten Hove & Nishi (1996), and confirmed in the present study, that although collar chaetae are absent in adults, they are present in some juveniles. Hence, the use of absence of collar chaetae in *Pomatoleios* as a character to distinguish it from *Spirobranchus* would lead to an odd taxonomic situation in which juvenile *Pomatoleios* having collar chaetae are assignable to *Spirobranchus* and adults without them to *Pomatoleios*.

The three nominal genera cannot also be separated on the basis of their radiolar arrangement i.e., that it is spiral in the *Spirobranchus giganteus* and *Spirobranchus corniculatus* complexes, but circular in the *Spirobranchus tetraceros*-complex, *Pomatoceros* and *Pomatoleios*. This is because, as described by ten Hove & Nishi (1996: 89) in *Spirobranchus corrugatus* Straughan 1967, for example, the radioles occur "in two perfect circles in small specimens," but in "1½ whorls in large specimens". There is also *S. paumotanus* (Chamberlin, 1919) dealt with later in this account, in which radioles are shown to be arranged in a circle in juveniles, but with up to 5 spirals in adults.

In a cladistic analysis Pillai (2008: 45) showed that according to criteria previously employed to separate the three genera, they belong to a cohesive group in which *Pomatoleios* is sister to the clade consisting of *Pomatoceros* & *Spirobranchus*. As a follow-up in the present paper, however, *Pomatoceros* and *Pomatoleios* are synonymized with *Spirobranchus* for the foregoing reasons.

Terminology relating to collar chaetae in *Spirobranchus*

The terminology hitherto used to describe collar chaetae of *Spirobranchus* poses some problems. As discussed earlier, the collar fascicle in serpulimorph polychaetes consists of two kinds of chaetae, special collar chaetae which are modified in various ways and are important in the taxonomy of its species, as well as those that end distally in simple blades. Where the special collar chaetae possess a recognizable boss and a blade, they have been termed bayonet-shaped or *Spirobranchus*-type. However, the latter descriptive term becomes inapplicable for the genus *Spirobranchus* as a whole since there is a complete range from bayonet-shaped to simple blades in the various species, as shown in this paper.

The second type of collar chaetae as well as those of the remaining thoracic segments have been termed "hooded chaetae", among others, such as simple limbate chaetae, simple bladed chaetae and bladed capillaries. However, if we are to define chaetae in relation to the Polychaeta as a whole, truly hooded chaetae, aptly termed "soies encapuchonnees" in the French literature, are found in certain other polychaete groups, such as the Spionidae and the Capitellidae, but absent in serpulimorphs. As to be expected, the "hoods" of hooded chaetae have an opening on one side in the former taxa, unlike in those described as hooded chaetae in sabellids and serpulimorphs. The terminology of serpulimorph chaetae is under review (ten Hove, personal comm.).

Abdominal neurochaetae of *Spirobranchus* have been described as having flattened trumpet-shaped ends with one side drawn into a long tapering process. However, these 'trumpet-shaped' ends gradually become reduced to such an extent that although they appear to be capillaries towards the posterior end of the abdomen, they are actually narrowly bladed at their tips, as also seen in many other serpulid genera.

Section 1: The Kimberleys' species of *Spirobranchus*

Spirobranchus baileybrockae n.sp.

Fig. 37A–H

Material examined. Kimberleys, Western Australia, HOLOTYPE lacking its tube, AM W21421; sandy cay on Port George 1V, 15°20'S 124°39'E, 12 Jul. 1988, st 26; coll. P.A. Hutchings.

Description

Measurements. Total length 16.6 mm; width of thorax 2.5 mm; length of operculum and peduncle 6.0 mm; length of shortest opercular horn (occurring dorsally) 2.0 mm, longest horn (occurring ventrally) 2.3 mm; length of abdomen 7.9 mm; number of abdominal segments 65.

Tube. Missing.

Worm. Radioles colourless and translucent, thorax and abdomen opaque and colourless; opercular plate white, with a translucent rim, its horns white with transparent medial and lateral spines; operculum on left, rudimentary operculum absent; opercular plate circular, bearing a circle of 8 very long horns and a short central process (Fig. 37A–C). Each long horn bears a row of somewhat long usually 3, sometimes 4, pointed medial spines, and short lateral spines (Fig. 37C); medial spines unbranched, those towards the base comparatively longer and hooked towards the centre; lateral spines may bear 2 or 3 smaller spines. Peduncle winged, wings unfringed (Fig. 37A,B). Radioles: 23 on each side, arranged in a circle, their pinnule-free tips short and thick, pinnules very fine. Inter-radiolar membranes unfringed. Collar large, its ventral lobe triangular, lateral lobes rounded and reach third or 4th thoracic chaetiger; 7 thoracic chaetigers; apron present.

Chaetae. Special collar chaetae bayonet-shaped (Fig. 37D,E), lack an unserrated notch; a rasp-like area of the chaetal shaft precedes the boss; chaetal blade longer than serrated part of shaft plus boss; serrations along distal part of chaetal shaft ventral and ventrolateral. Thoracic uncini saw-shaped (Fig. 37F), with 12 or 13 teeth and an anterior gouged process; anterior abdominal uncini (Fig. 37G) similar but smaller, with about 10 teeth; posterior abdominal uncini (Fig. 37H) still smaller, bear about 12 teeth. Abdominal chaetae with long shafts protruding prominently from abdominal wall occur from first abdominal segment onwards.

Remarks. *Spirobranchus baileybrockae* n.sp. is identical with regard to all the important characters of the worm described by Bailey-brock (1985: 204, fig. 8a–f) from Fiji as variant forms of *Spirobranchus tetraceros* (Schmarda, 1861). Although the latter were not examined in this study, Bailey-Brock's very good descriptions of the two Fijian specimensare adequate for the discussion and conclusions which follow. Firstly, although the tube of the Kimberleys holotype is missing, Bailey-Brock's description of it in two specimens is in contrast with that of *S. tetraceros*. In the larger of the two, tube colour is "salmon-pink with a faint rose tinge to the anterior part of median ridge"; in the smaller specimen, the earlier formed part of the tube is white, "vivid rose-pink" along the median longitudinal ridge and extending anteriorly towards the aperture. As regards tube shape, that of the larger specimen is triangular in cross-section, has broad lateral flanges, and a well-formed sinuous median

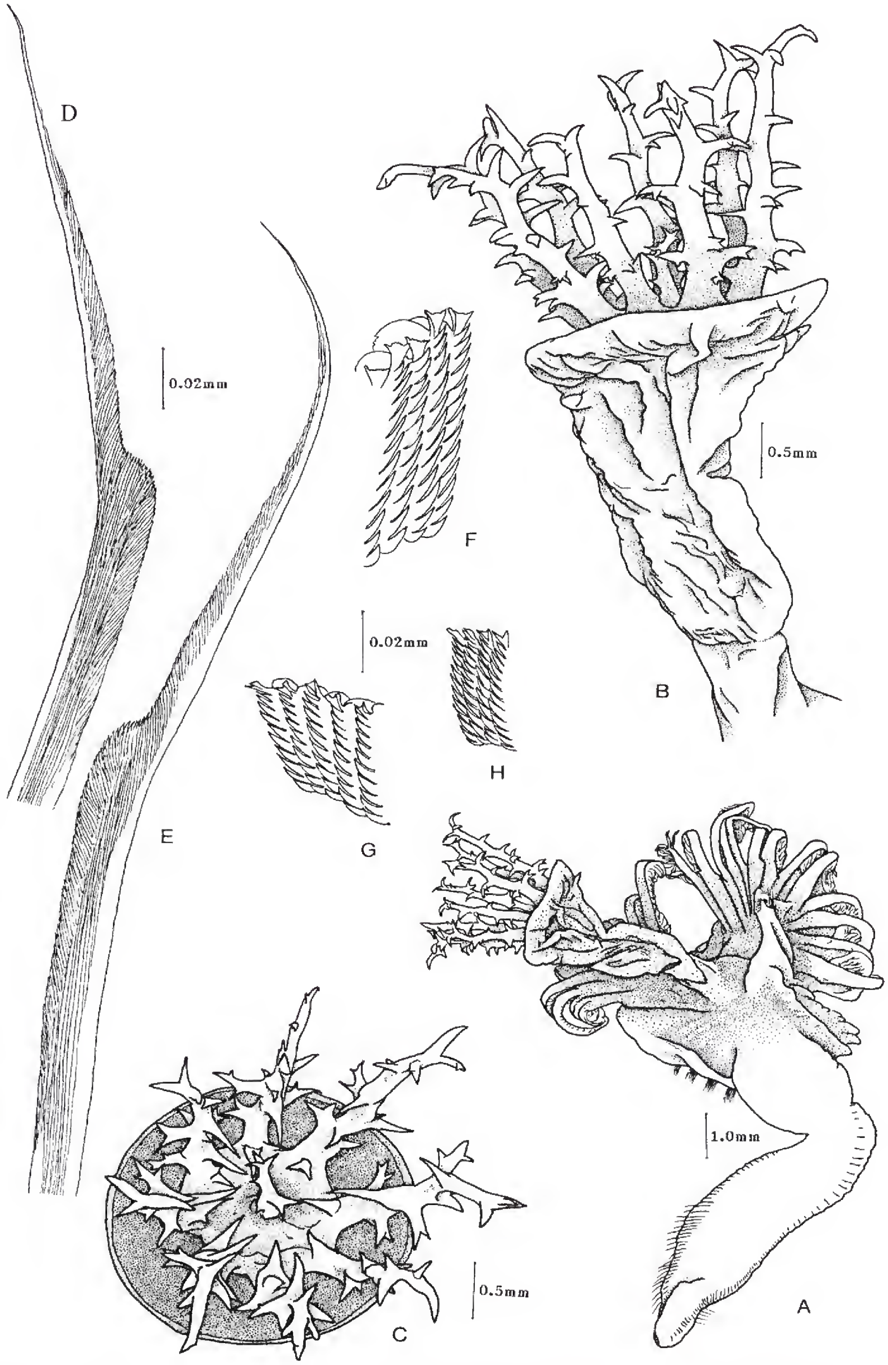

Figure 37. A–H, *Spirobranchus baileybrockae* n.sp. from holotype, AM W21421: (*A*) dorsal view of whole worm; (*B*) right dorsolateral view of operculum; (*C*) operculum viewed from anterior end; (*D,E*) bayonet-shaped special collar chaetae; (*F*) thoracic uncini; (*G*) anterior abdominal uncini; (*H*) posterior abdominal uncini.

longitudinal ridge which projects conspicuously over the aperture, and its surface is pitted on the sides and flanges giving it a somewhat "foraminous appearance". On the other hand, tube-colour in *S. tetraceros* (Schmarda, 1861) as observed in the Kimberleys collection is white in adults, may be white to bluish-grey in juveniles, but not pink or rose, and does not have a pitted surface and a "foraminous appearance".

Secondly, the number and form of the main opercular horns in the Kimberleys holotype agree fully with Bailey-Brock's Fijian specimens. In both they consist of a circle of 8 long unbranched horns, which are not dichotomously branched, each bearing a regular single row of medial spines, as well as a short dichotomously-branched spine arising from the centre of the latter circle of long spines. In contrast, the number of main horns in *S. tetraceros* from the Kimberleys is 3, and they are dichotomously branched. Furthermore, inter-radiolar membranes are not fringed in *S. baileybrockae* but fringed in *S. tetraceros*.

Another species that needs to be compared with *S.*

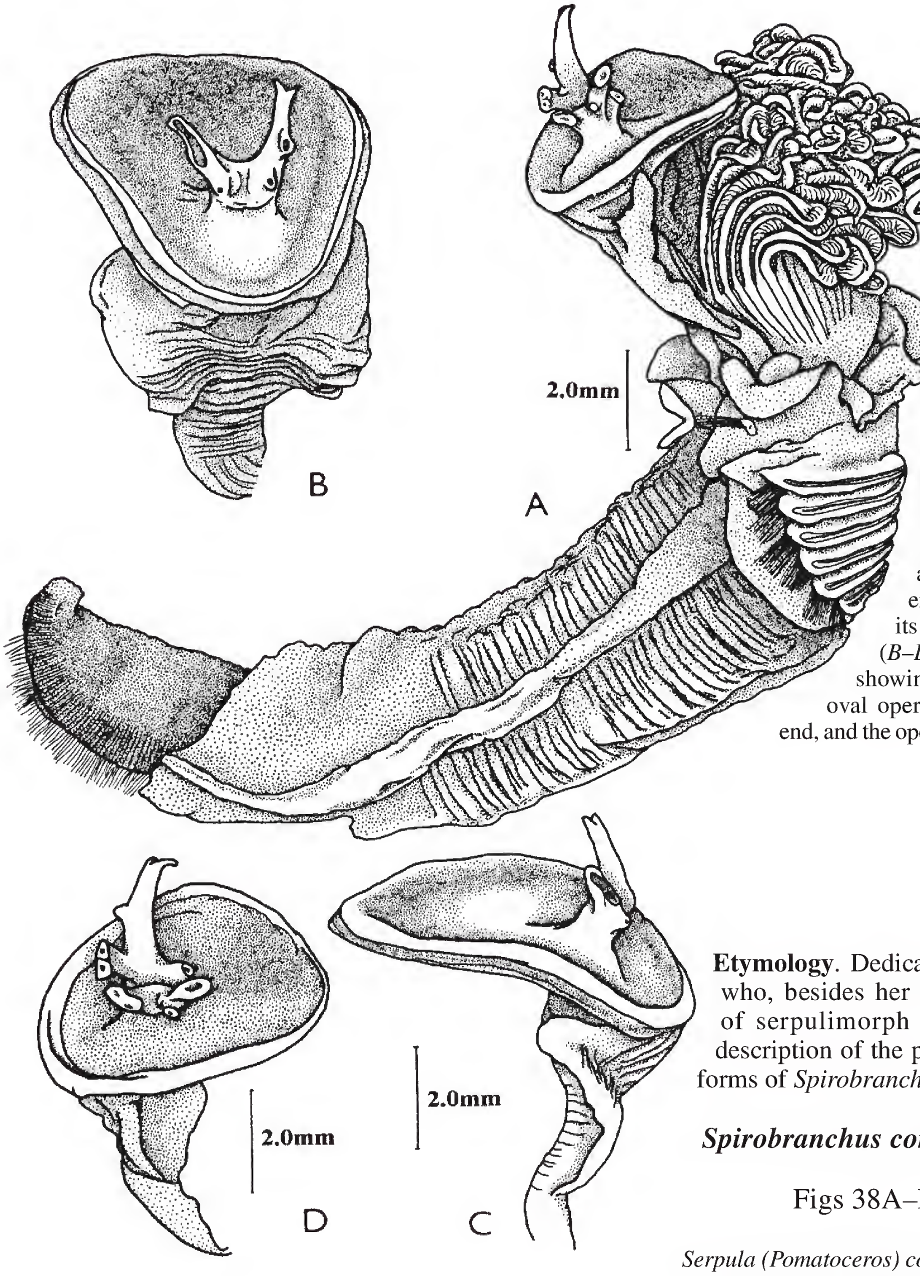

Figure 38. A–D, *Spirobranchus corniculatus* (Grube, 1862) from AM W202960: (*A*) complete specimen showing its single median longitudinal ridge, fine transverse ridges alternating with fine fine grooves on either side of it, and the worm showing its unfringed inter-radiolar membranes; (*B–D*) different views of the operculum showing the unfringed peduncular wings, oval opercular plate with a broader anterior end, and the opercular horns located posteriorly on it.

baileybrockae is *S. coronatus* Straughan (1967). It has been described as possessing 8–10 main opercular horns. However, differences in their form distinguish it from the present species. While the opercular horns in *S. baileybrockae* and *S. tetraceros* are directed anteriorly (more or less perpendicularly to the opercular plate), those in *S. coronatus* are directed radially (more or less flattened along the plane of the opercular plate), and bear numerous lateral processes. While the 8 long spines in *S. baileybrockae* are not dichotomously branched, they are dichotomously branched in *S. tetraceros* and *S. coronatus*. Moreover, *S. coronatus* lacks the row of 3 or 4 pointed medial spines along each main spine, as well as the short dichotomously branched horn arising from the centre of the circle of main horns, which are characteristic of *S. baileybrockae* (Fig. 37C). Furthermore, inter-radiolar membranes are unfringed in *S. baileybrockae*, but fringed in *S. coronatus* and *S. tetraceros*.

Etymology. Dedicated to Dr Julie H. Bailey-Brock who, besides her contributions to our knowledge of serpulimorph polychaetes, provided a good description of the present species in 1985 as variant forms of *Spirobranchus tetraceros* (Schmarda, 1861).

Spirobranchus corniculatus (Grube, 1862)

Figs 38A–D, 39A–J, 40A–C

Serpula (Pomatoceros) corniculata Grube, 1862: 66, fig. 5.
Pomatocerus bucephalus.—Mörch (1863: 411, fig. 26), Quatrefages (1865: 520–521), as *Vermilia bucephala* (Mörch, 1863).
Spirobranchus giganteus.—Straughan, 1967: 245, fig. 14e.
Spirobranchus giganteus corniculatus (Grube, 1862).—ten Hove (1970: 24); Imajima (1976: 136, fig. 9a–p).
?*Spirobranchus gaymardi* (Quatrefages, 1866).—Fiege & ten Hove (1999: 355–364).

Material examined. Kimberleys, Western Australia: 5 specimens, AM W202960, Condillac Island, 14°06'S 125°33'E, sand with scattered bommies, intertidal, 0 m, 16 Jul. 1988, st 54; 3 specimens, AM W202959, Condillac Island, 14°06'S 125°33'E, sand with scattered bommies, intertidal, 6 m, 16 Jul. 1988, st 54. 1 very large specimen, AM W202958, Albert Island, 14°31'S 124°55'E; 1 specimen, AM W202952, West side of Cassini Island, 13°57'S 125°37'E, low tide, 18 Jul. 1988, st 59; 3 specimens, AM W21426, Condillac Island, 14°06'S 125°33'E, sand with scattered bommies, intertidal, 6 m, 16 Jul. 1988, st 54; all coll. P.A. Hutchings.

Additional material examined. Hulule, Male Atoll, Maldives, BMNH 1938.7.25.2, labelled Type, *Spirobranchus giganteus* var. *turbinatus*, J.S. Gardiner.

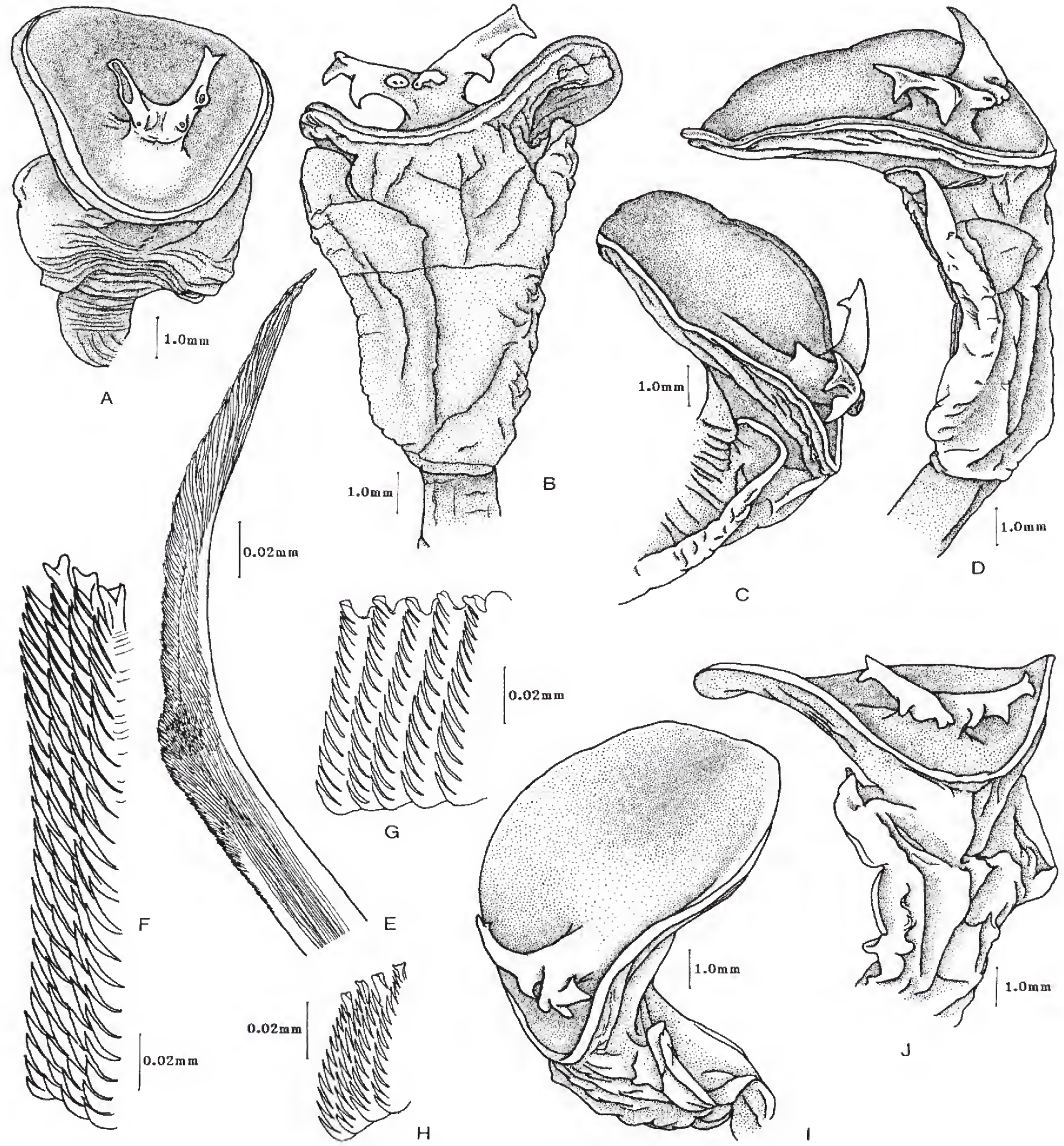

Figure 39. A–J, *Spirobranchus corniculatus* (Grube, 1862). A–H, from AM W202959: (*A*) anterodorsal view of operculum of a specimen; B–H, operculum of another specimen; (*B–D*) dorsal, left anterolateral and left lateral views of operculum [C, shows a small conical process is present on the common basal column of the opercular horns, a variable character]; (*E*) bayonet-shaped special collar chaeta; the serrations along the distal part of the blade are conspicuously long (*F*) thoracic uncini; (*G*) anterior abdominal uncini; (*H*) posterior abdominal uncini. I,J, operculum of a specimen from AM W202958: (*I*) right anterolateral view; (*J*) dorsal view; a conical process is not present on the common stem from which the opercular horns arise, unlike in the specimen figured in C.

Description

Measurements. Only one out of the 5 specimens in AM W202960 has an undamaged tube; its maximum external diameter, 4.7 mm. Specimens in AM W202959 are larger; maximum external tube diameter of 11.5 mm and tube thickness of 2.0 mm; however, the worm is incomplete. The largest worm has a total length of 43.8 mm, and about 217 abdominal segments. The largest thoracic width of 7.7 was encountered in the incomplete specimen from AM W202958. The largest operculum, together with its peduncle and horns is 13.5 mm long, horns alone 3.2 mm. Long and short diameters of the opercular plate in an older specimen, AM W202959, 7.5 mm and 6.5 mm, respectively.

Tube. Tube colour ranges from yellowish orange in specimens from AM W202960, to bright orange, both externally and internally, and in the very large incomplete specimen from AM W202958. Tube of small complete specimen from AM W202960 has a single, somewhat smooth, median longitudinal ridge, with fine transverse ridges on either side of it (Fig. 38A).

Worm. Colour: opercular plate rose coloured in four out of five specimens in AM W202960 white in fifth; white, and its rim and horns bright pink in one specimen; bright pink, especially its rim, and tips of opercular horns, in another, from AM W202952.

Operculum occurs on left side in all specimens,

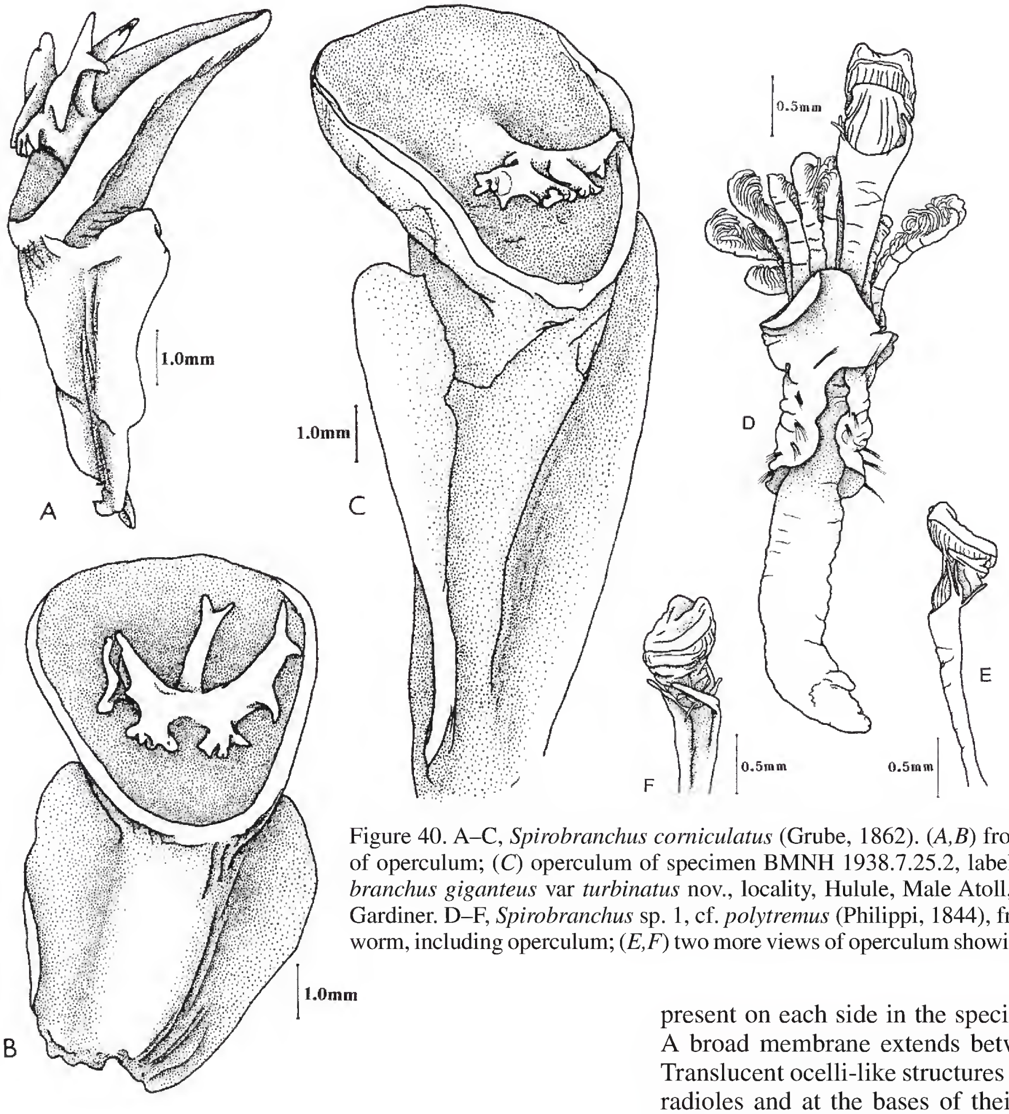

Figure 40. A–C, *Spirobranchus corniculatus* (Grube, 1862). (*A,B*) from AM W202960, two views of operculum; (*C*) operculum of specimen BMNH 1938.7.25.2, labelled type specimen of *Spirobranchus giganteus* var *turbinatus* nov., locality, Hulule, Male Atoll, Maldives, collected by J.S. Gardiner. D–F, *Spirobranchus* sp. 1, cf. *polytremus* (Philippi, 1844), from AM W21404: (*D*) whole worm, including operculum; (*E,F*) two more views of operculum showing fringed peduncular wings.

rudimentary operculum absent; opercular plate oval, the broader part being anteroventral, the whole having a posterodorsal slope (Fig. 38A–D, 39A,C,D,I,J, 40A–C). As also seen in latter figures, a pair of horns, borne on a short common base arises posterodorsally from it; each horn has a short bifid dorsomedial spine towards its base, a short posterolateral spine towards its middle, and ends in a bifid tip. Tips of main horns and spines are wasted through abrasion against the tube, the operculum evidently being withdrawn obliquely into the tube, unlike in other species of *Spirobranchus*. Peduncular wings unfringed (Figs 38A–C, 39A,B, 40A–C). Variations observed in arrangement of spines on the opercular horns: in an older specimen from AM W202959, tips of the main horns curved, pointed, and directed anteroventrally (Fig. 39B–D), as also figured by Mörch (1863: fig. 26). In addition, a small, anteriorly directed conical swelling may be present at the base of the short column from which the main horns arise (Fig. 39C), apparently uncommon; latter is lacking in specimen shown in (Figs 38C, 39I, 40C). A long medial process may occasionally be present in place of the conical process (Fig. 40A,B). Radioles numerous and arranged spirally on each side. Four out of the five specimens in AM W202960 possess 7 spirals on each side, the fifth 5. However, 10 spirals are present on each side in the specimen from AM W202958. A broad membrane extends between the radiolar whorls. Translucent ocelli-like structures present laterally along the radioles and at the bases of their pinnule-free tips. Interradiolar membranes unfringed (Fig. 38A). Highest number of abdominal segments counted, 226 in a worm from AM W202959. Long-shafted neurochaetae and notopodial uncinal tori are present in all except the first 3–6 or so abdominal segments.

Chaetae. In bayonet-shaped special collar chaetae (Fig. 39E), a serrated area of the chaetal shaft precedes boss; latter squarish, prominent; unserrated notch absent between boss and blade; serrations along distal part of blade elongated and wavy, those of proximal part much shorter; blade about twice as long as combined length of the serrated part of chaetal shaft plus boss. Uncini saw-shaped, anterior process gouged; thoracic uncini (Fig. 39F) very long compared to those of the other species of *Spirobranchus*, and with a higher number of teeth, around 22 to 24; anterior abdominal uncini much smaller, with about half the number of teeth (Fig. 39G); posterior abdominal uncini similar, with about 13 teeth (Fig. 39H).

Remarks. *Spirobranchus corniculatus* is a widespread Indo-Pacific species (see ten Hove 1970: 14). Material described as *S. giganteus* (Pallas) by Straughan (1967: 243) from Queensland, with its characteristic oval operculum and structure of opercular horns (Straughan, 1967: fig. 14e), belong to *S. corniculatus*. Likewise, specimen BMNH

1938.7.25.2, from Hulule, Male Atoll, Maldives, labelled type specimen, and as a new variety *Spirobranchus giganteus* var. *turbinatus*, by J.S. Gardiner, which was examined during the present study, also is *S. corniculatus*. It is very large, and has a total length of 90.3 mm; its operculum is shown in Fig. 40C. However, its radioles are arranged in only 6 spirals on each side, compared to the highest number recorded during this study. The number of abdominal segments is 226. The largest worm from Kimberleys AM W202960, however, has a total length of 43.8 mm, half that of the above specimen from the Maldives, and about 217 abdominal segments. The highest number of abdominal segments observed is 226 in a worm from Kimberleys collection AM W202959.

The highest number of branchial whorls is 10 on either side in a specimen from AM W202958. Its special collar chaetae bear serrations, which are, as described earlier, long and wavy. Its thoracic uncini bear up to about 21 teeth, in addition to the anterior gouged process; and anterior abdominal uncini, about 11 teeth.

In a larger specimen of *S. corniculatus* in BMNH 1970.853 from Matur Island, Solomon Islands, collected and presented to the NHM by P.E. Gibbs in 1970, the radioles are arranged in 8 spirals on each side. Opercular peduncle and inter-radiolar membranes are unfringed. Abdominal uncinal tori are lateral, starting from about 7 or 8 segments from the anterior end; long-shafted abdominal chaetae present throughout the abdomen.

In a very much larger specimen, in BMNH 1970.82, collected by P. Gibbs from Paleki Islands, LWM, during the Royal Society Expedition to the Solomon Islands, and identified as *S. giganteus corniculatus* by ten Hove, 7.9.95, of total length 99.5 mm, has only 8 radiolar spirals on each side.

Although *S. bucephalus* (Mörch, 1863), based on *Pomatoceros bucephalus* Mörch (1863: fig. 26) from Java, and accompanied by a more accurate description.existed asan alternative for *S. corniculatus*, Grube's description came out earlier, in 1862, and has priority in terms of the rules of Nomenclature

See ten Hove (1970) for past records of *S. corniculatus* from the Philippines, Indonesia, New Guinea, New Caledonia, Marshall Islands, Australia, Japan, Maldives, Sri Lanka, S. Arabian Coast, Red Sea, East Africa, Madagascar and South Africa.

Spirobranchus sp. 1, cf. *polytremus* (Philippi, 1844)

Fig. 40D–F

Material examined. Kimberleys, Western Australia, 2 specimens, without their tubes, AM W21404, Bernouli Island, 15°00'S 124°47'E, 12 Jul. 1988, st 30; coll. P.A. Hutchings.

Description

Measurements. Total lengths 7.0 mm and 6.7 mm; widths of thorax 1.0 and 0.9 mm; lengths of operculum and peduncle 3.0 mm and 2.7 mm; abdomen incomplete in first specimen, 2.8 mm long in second. Number of abdominal segments in complete specimen: 41, with capillaries commencing from the 33rd.

Tube. Missing.

Worm. Operculum calcareous; occurs on left side in both specimens, rudimentary operculum absent. Opercular plate bears a pair of rounded lobes (Fig. 40D–F) similar to that described for *S. polytremus* (Philippi, 1844); peduncle winged, the latter fringed (Fig. 40F). Branchial radioles arranged in a circle on each side; 7 pairs of radioles in first specimen; 6 on the left and 7 on the right in second; pinnule-free tips moderately long and thick. Thoracic chaetigers number 7. Apron: present.

Remarks. It had been previously shown (Zibrowius, 1968; Imajima, 1977, 1998; Bianchi, 1981; Ben-Eliahu, 1996) that *Pomatostegus polytrema* (Philippi, 1844) is indeed a *Spirobranchus*, since its operculum is calcareous, unlike in *Pomatostegus* in which it is chitinous.

From various past descriptions from the Indo-Pacific area, it appears that there are a number of *Spirobranchus polytremus*-like species, which need to be sorted out. A good example is that of the types A and B of this complex described by Imajima (1977: 102–106). Imajima remarks that "It is unlikely that" the species described by him "will prove to be the same as the Mediterranean species". However, regarding the "complexity of the group involved, the confusion of names by previous authors, and the scarcity of data on infraspecific variation of the individual species, it appears best not to introduce another name, and await a full-scale revision of the group." For the same reason, the Kimberleys specimens are therefore not named.

It would be useful, however, to note the differences among the Mediterranean *S. polytremus*, the similar Kimberleys specimens described above, and other similar species described from the Indo-West Pacific. According to Zibrowius (1968), the tube of *S. polytremus* (Philippi, 1844) from the Mediterranean possesses a well-developed MLR and a pair of LLR's on either side of it, with rows of pits at their bases. According to Bianchi (1981: fig. 41A,B) its colour is white, but may be faintly rose or violet. The description of the tubes by Ben-Eliahu & Fiege (1996) agrees with that of both Zibrowius and Bianchi: "Characteristic tubes triangular in cross section with tiny pits at medial and lateral keels (some with faint pink cast), and with typical internal cellular chambers within the lower lateral parts…"

The worm in *S. polytremus*, according to Zibrowius (1968), possesses about 9 radioles, the operculum occurs in the position of the most dorsal radiole of the left side, the peduncle is winged and the wings are not fringed. In the Kimberleys described above are different in that their peduncular wings are fringed (Fig. 39D–F); and the maximum number of radioles is 6, but confirmation is required as to whether there are larger sizes with a higher number of radioles or not.

Among the similar species from the Indo-West Pacific: *Temporaria polytrema* from New South Wales (Straughan, 1967) and Sri Lanka by (Pillai, 1971), the synonymies of which had previously been dealt with, and specimens of a very small *S. polytremus*-like species collected by the present author from Jayapura, West Irian (Indonesia) in 1969/70 and passed on to ten Hove. *Spirobranchus oligotremus* (Straughan, 1967) is another. Straughan (1967) states that the former has about 8 pairs of radioles arranged in a spiral and inter-radiolar membrane are absent. It is unusual for a *Spirobranchus* to have such a low number of radioles spirally arranged on each side. In other *S. polytremus*-like species, however, the radioles are arranged in a circle on each side and inter-radiolar membranes are present.

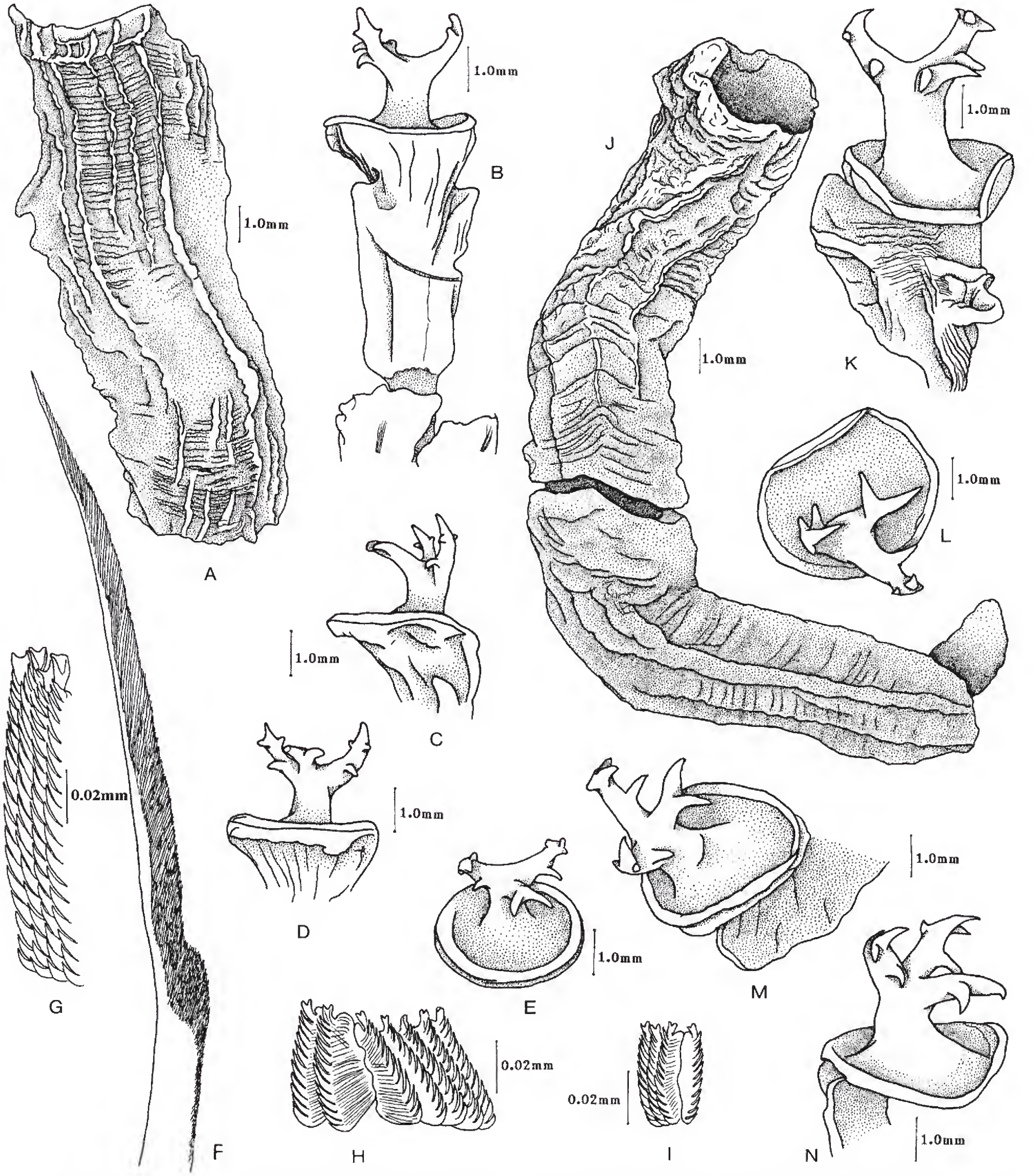

Figure 41. A–N, *Spirobranchus richardsmithi* n.sp. A–I, from holotype AM W21433: (*A*) tube, viewed from above; longitudinal ridges damaged in its middle part during removal of encrusting coral. B–E, different views of operculum: (*B*) dorsal view of operculum and peduncle; (*C*) left lateral view; (*D*) anteroventral view; (*E*) anterior view. F–I, chaetae: (*F*) bayonet-shaped special collar chaeta; (*G*) thoracic uncini; (*H*) anterior abdominal uncini; (*I*) posterior abdominal uncini. J–M, from a paratype: (*J*) tube; K–M, operculum: (*K*) right ventrolateral view; (*L*) anterior view; (*M*) left anterolateral view; (*N*) operculum of another another paratype, left lateral view.

Spirobranchus richardsmithi n.sp.

Figs 41A–N, 42A–H, 43A–K

Spirobranchus giganteus corniculatus.—Bailey-Brock (1985: 203, fig. 6a–c).

Spirobranchus gardineri.—Fiege & Sun (1999: 126, fig. 15A,B).

Type material. Kimberleys, Western Australia: HOLOTYPE and 3 PARATYPES, all AM W21433, east of Montalivet Island, 15°06'S 125°88'E, intertidal, 6 m, 16 Jul. 1988, st 50; coll. P.A. Hutchings.

Additional material examined. Kimberleys, Western Australia: 5 specimens, AM W21442, Long Reef, 13°58'S 125°38'E, 25 m, 17 Jul. 1988, st 58; empty tubes, AM W21444, Long Reef, 13°58'S 125°38'E, 25 m, 17 Jul. 1988, st 58. 1 early juvenile specimen, AM W21474, south west corner of Lucas Island, 15°13'S 124°31'E, underside of coral, 30 m, 24 Jul. 1988, st 101; all coll. P.A. Hutchings.

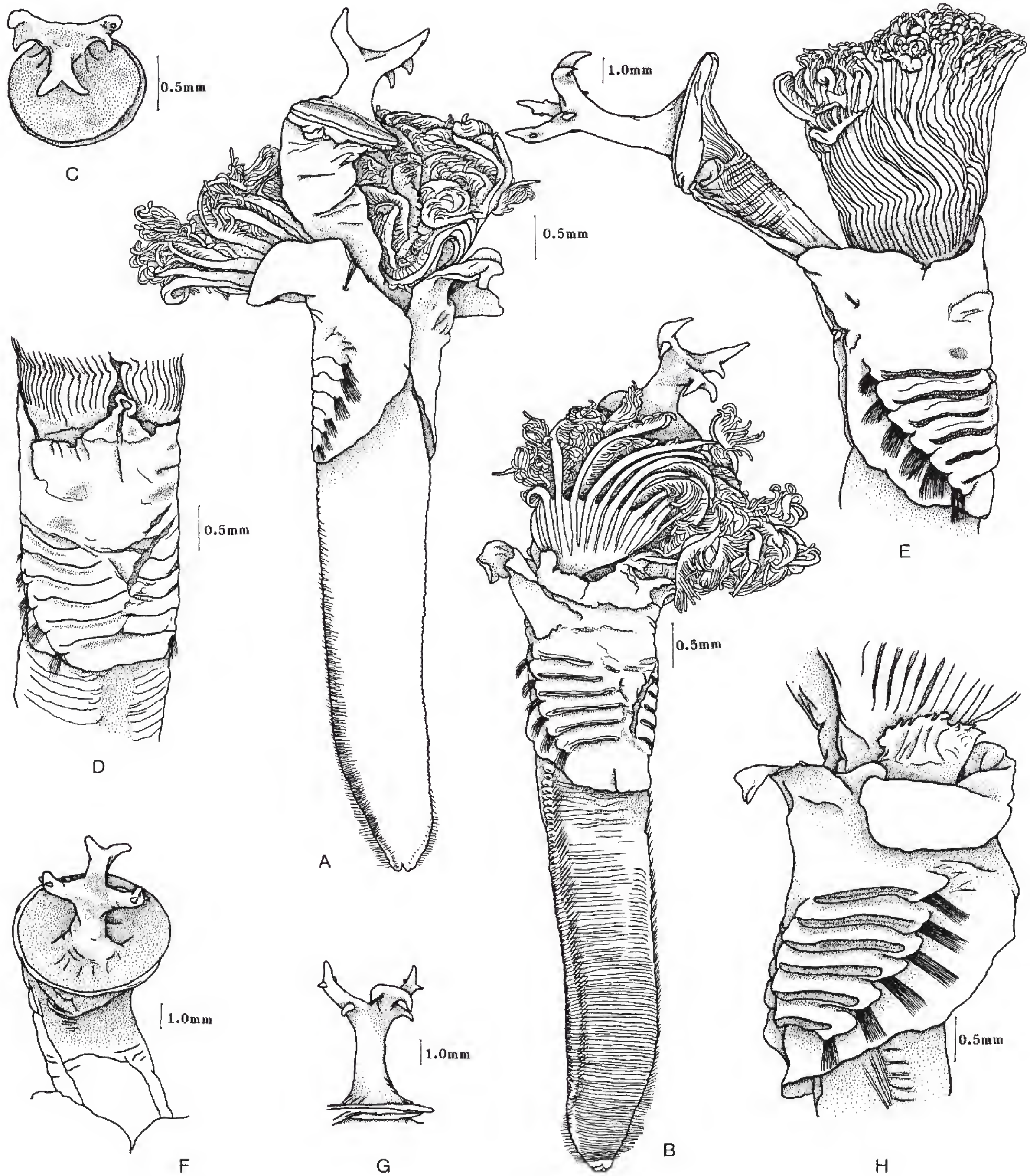

Figure 42. A–H, *Spirobranchus richardsmithi* n.sp. from specimens in AM W21442. A,B,E–G, from same specimen. (*A,B*) dorsal and ventral views, respectively, of the whole worm. Note the abdominal chaetae with long shafts; (*C*) from second specimen: opercular horns and disc viewed from the anterior end. D–H, from third specimen: (*D*) ventral view of thorax; (*E*) right lateral view of operculum and thorax; (*F,G*) dorsal and right ventrolateral views of operculum; (*H*) lateral view of thorax, collar and anterior part of abdomen, showing fringed membrane between dorsolateral lobe of collar and base of the radioles, and long-shafted chaetae in anterior part of abdomen.

Description

Measurements. All tubes found growing on and covered over by coral. Holotype, AM W21433: tube diameter, 6.5 mm; total length of complete worm in latter 42.4 mm, its thoracic width, 3.5 mm; length of operculum and peduncle 10.7 mm, and the opercular horns 3.5 mm; abdomen 33.7 mm long, and the number of abdominal segments about 145. Largest tube diameter, 7.0 mm, occurs in one of the paratypes in AM W21433. Total lengths of specimens from AM W21442 range from 9.5 mm to 40.9 mm, the latter almost the same size as the largest from AM W21433. Smallest specimen, from AM W21442, has a total length of 9.5 mm. However, the early juvenile in AM W21474 has a maximum external tube diameter of 0.5 mm; total length of worm 4.4 mm, its thorax 0.4 mm wide, length of operculum

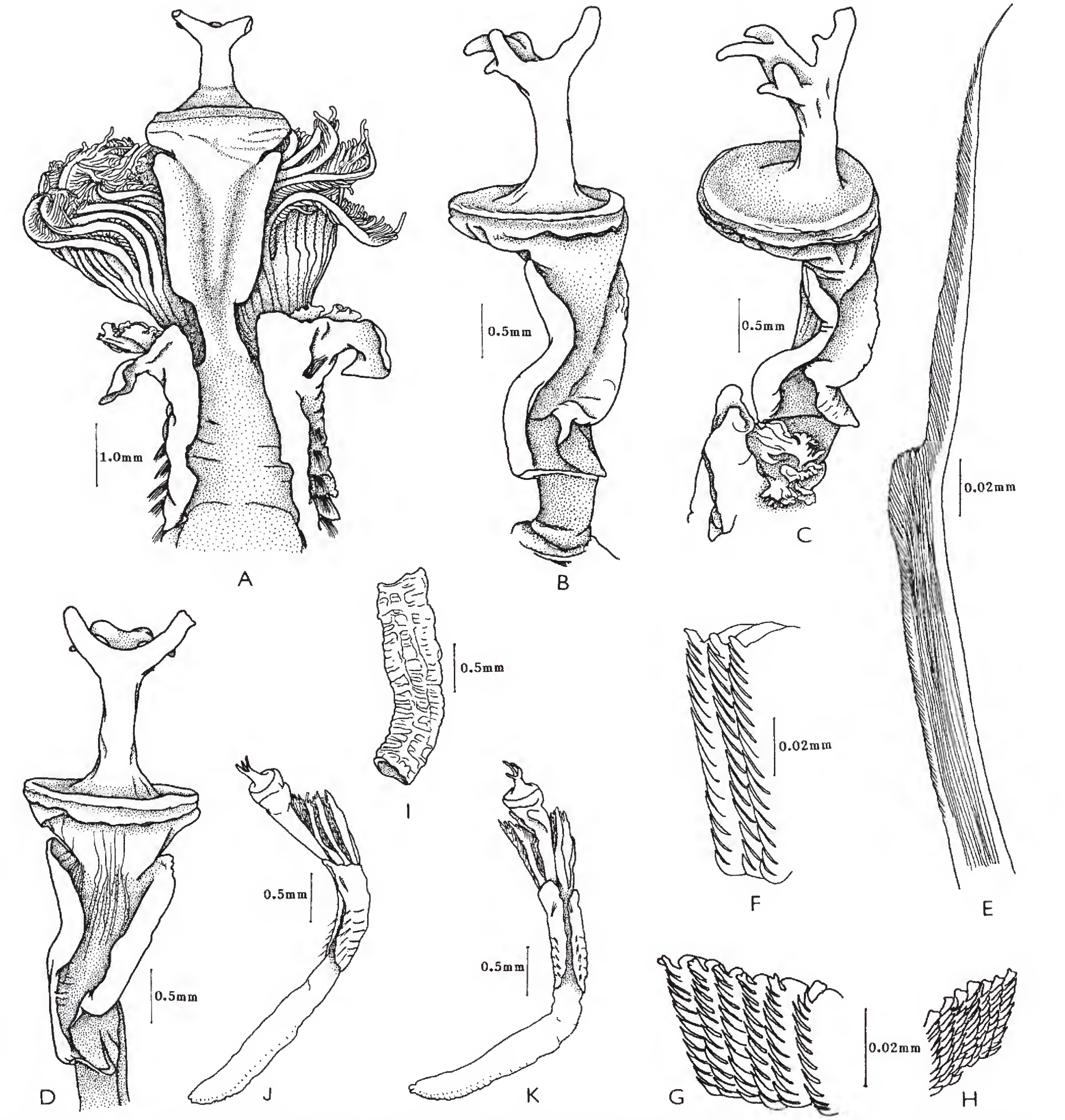

Figure 43. A–H, *Spirobranchus richardsmithi* n.sp. A–H, from aberrant specimens in AM W21433: (*A*) anterior end of worm showing opercular disc and processes, unfringed opercular wings and pinnule-free tips of radioles; (*B–D*) three views of the operculum of another specimen showing the circular opercular disc, abnormal opercular processes, and unfringed opercular wings; (*E*) bayonet collar chaeta; (*F*) thoracic uncini; (*G*) anterior abdominal uncini; (*H*) posterior abdominal uncini. I–K, early juveniles of *Spirobranchus richardsmithi*, from AM W21442. I,J, from smallest specimen: (*I*) dorsal view of tube with worm *in situ*, showing the single median longitudinal ridge and fine transverse ridges on the tube and the anterior end of the worm; (*J*) right dorsolateral view of operculum; (*K*) dorsal view of another juvenile showing left anterolateral view operculum.

and peduncle 1.7 mm, length of operculum alone, 0.5 mm, and the length of abdomen 1.7 mm.

Tube. Tube colour of holotype: mauve patches on a white background; paratypes: one has a darker mauve coloration than others; overall colour range of tubes in all material studied yellow to yellowish brown, and light to dark mauve. Holotype shows a low median longitudinal ridge and 4 or 5 narrower ones on either side of it (Fig. 41A), while a paratype is similar, but its lateral ridges are less clearly developed (Fig. 41J); fine transverse ridges present throughout (Fig. 41A,J).

Worm. Opercular plate in holotype white; pinkish to bright pink in older specimens; horns white, pinkish to purplish in places. Operculum occurs on left in all specimens; no rudimentary operculum on right. Based on several specimens of varying sizes, operculum circular in juveniles and intermediate sizes (Figs 41E, 42A,C,E,F); somewhat oval in some older specimens (Fig. 41M,N). Arising vertically from opercular plate in holotype is a column bearing a pair of dorsolateral horns and a bifid ventromedian horn (Fig. 41B–E); tips of ventromedian horn curved towards opercular plate. Dorsolateral horns not dichotomously branched (Fig. 41B–E); each ends in an anteroventrally curved, more or less pointed tip, and bears three short accessory spines, one located ventrolaterally towards its middle or at the point where it joins the central column, and the other two located sub-terminally; paratypes and other specimens similar (e.g., Figs 41K–N, 42A–E). Central column itself may be short and stout as in holotype (Fig. 41B–E) and other specimens (e.g., Fig. 42A,B), or comparatively longer and less stout (Fig. 42E,G). Peduncular wings unfringed in holotype and paratypes (Fig. 41B,C,K), and all other specimens similar (e.g., Fig. 43A–D,K).

Radioles numerous, arranged in 4½ whorls on each side in holotype, the maximum number observed; up to 3½ whorls in other specimens; smallest specimen (from AM W21442) has 19 radioles plus the operculum on the left and 25 radioles on the right, arranged in a partial spiral on both sides. Inter-radiolar membranes unfringed (Fig. 42B); pinnule-free radiolar tips as long as, and of same thickness as the pinnules. A pair of blackish clusters of prostomial ocelli present ventrolaterally, anterior to the first pair of thoracic tori (Fig. 42E). Seven thoracic chaetigers; the distances between corresponding pairs of thoracic tori decreasing toward thorax where they meet or almost meet; apron present (Fig. 42B,D,E,H); Number of abdominal segments 145 in holotype; maximum number in 165 in one of the other specimens.

Chaetae. Special collar chaetae bayonet-shaped, possess a serrated area along the shaft preceding the squarish basal boss (Fig. 41F in holotype and Fig. 43E, in another specimen); blade, only slightly longer than serrated part of chaetal shaft plus boss; unserrated notch absent; boss may be abraded. Thoracic uncini: saw-shaped, bear about 15–20 teeth and an anterior gouged process (Fig. 41G in holotype; Fig. 43F in another specimen). Anterior abdominal uncini (Figs 41H for holotype; Fig. 43G for another specimen) bear about 10–13 teeth plus anterior gouge. Posterior abdominal uncini (Figs 41I for holotype; Fig. 43H for another specimen) are smaller but bear similar number of teeth. Abdominal neurochaetae with long shafts present throughout the abdomen (Fig. 42B,H).

Two specimens in the collection appear to be aberrant. Although similar to the above in having a circular opercular plate and three horns arising from a long central column, the horns themselves differ, as follows: In the smaller one (Fig. 43A), the dorsolateral pair of horns are blunt and appear abraded, while all horns are blunt in the other (Fig. 43B–D). However, bayonet-shaped special collar chaetae (Fig. 43E) are similar to those described earlier. Thoracic uncini similar, but bear a lower number, about 15 teeth in a single row, and an anterior gouged process (Fig. 43F); anterior and posterior abdominal uncini similar and bear about 10 and 9 teeth, respectively (Fig. 43G,H).

In the juvenile specimens from AM W21442: tube white, bears traces of two longitudinal ridges and faint transverse ridges (Fig. 43I). Operculum on left side, no rudimentary operculum on right; opercular plate circular, flat (Fig. 43J,K), bears a central column at the end of which are three rudiments of soft, unbranched, tapering horns; peduncle winged; wings unfringed. Radioles number 6 per side, arranged in a circle on either side, as to be expected in early juveniles; inter-radiolar membranes present; number of thoracic chaetigers 7; abdomen consists of 25 segments; neurochaetae with long shafts protruding conspicuously from the abdominal wall present from about segment 15; abdominal uncinal tori short and lateral.

Remarks. *Spirobranchus richardsmithi* n.sp., is superficially similar to *S. gardineri* Pixell, 1913 with regard to the circular opercular plate and column arising from it bearing three processes distally. However, unlike in the present species, the three distal processes in *S. gardineri* are not bifurcated, and are directed anteriorly *S. gardineri* as described by Pixell (1913: 81, plate 8, fig. 7a–c), and as confirmed by ten Hove (1994) in material from the Seychelles and Amirantes, directed “away from the opercular plate”. According to the latter, “forms with re-curving ventral spines occur in the Indo-West Pacific too; may be the taxon *gardineri* contains two species.” Pixell (1913) also mentions that the three anteriorly directed processes “sometimes give rise to short secondary branches”. A very important character of *S. gardineri* relates to the size and proportions of its thoracic uncini. As stated and figured by Pixell (1913: 81, plate 7, fig. 7c), they are very large. It is confirmed after examination of Pixell’s slides (types) in the Natural History Museum during the present study that they are indeed quite unlike those of the other species dealt with in this account, in being extraordinarily long and bearing at least 25 teeth plus the anterior gouge.

Bailey-Brock (1985) describes material from the Fijian coral reefs similar to *S. richardsmithi* from the Kimberleys, but assigned them to *S. giganteus corniculatus* (*sensu* ten Hove, 1970). Smith (*unpublished thesis*, 1985) describes similar forms from Queensland, in which the most ventral of the three processes at the end of the common column is bifid, which he refers to *Spirobranchus gardineri*, Pixell, 1913 (*sensu stricto*), with two variant types. However, specimens from the Seychelles and Amirantes studied by ten Hove (1994) agree with those described by Pixell (1913) in that all the spines at the distal end of the common column are directed anteriorly, i.e., away from the opercular plate. The single very large specimen described above and identified by by Bailey-Brock (1985: fig. 6a–c) therefore appears to belong to the new species, *S. richardsmithi*. Its opercular plate is circular, unlike in *S. corniculatus*, described earlier in this account, in which it is oval, and, as in *S. richardsmithi*, the two dorsolateral processes arising from the central column are curved anteroventrally, while and tips of its bifid ventral process are curved towards the opercular plate.

Another synonymy is that of *S. gardineri* Pixell, 1913, described from Hainan, South China Sea by Fiege & Sun, (1999: 126). The number of teeth in the thoracic uncini, in addition to the gouged process, in the Kimberleys material of *S. richardsmithi* is about 15–20, while it is 20–21 in the specimens from Hainan. As shown above, it is much higher, about 26, in *S. gardineri* (Pixell, 1913). Fiege & Sun also state that although the tubes are embedded in coral, with only their openings visible, they have a purplish interior, which is similar to the mauve tube colour of *S. richardsmithi* from the

Kimberleys, so suggesting that it belongs to the latter species.

The early juvenile of *S. richardsmithi* described above shows a possible plesiomorphous condition in an ancestor from which *S. gardineri, S. richardsmithi* and an un-named species described later in this account could perhaps have been derived.

As seen from the drawings and notes kindly provided by ten Hove in 1996, the new species also occurs in Indonesia.

Etymology. Named after Dr Richard Smith who considered it to be a distinct species (1985, unpublished PhD thesis), and his interesting contributions to our knowledge of serpulimorphs.

Spirobranchus tetraceros (Schmarda, 1861)

Figs 44A–C, 45A–I, 46A–K

Pomatoceros tetraceros Schmarda, 1861: 30, plate 21, fig. 6, from New South Wales.

Spirobranchus tetraceros (Schmarda).—ten Hove (1970a, 3, for further synonymy, in part); ten Hove (1970a: 3–13, figs 1–25), Imajima (1986: 8).

?*Spirobranchus tetraceros*.—(Dew, 1959: 45, fig. 17).

Spirobranchus giganteus.—(Dew, 1959: 45, fig. 17).

Spirobranchus semperi Mörch, 1861.—Straughan, 1967: 246.

?*Spirobranchus tetraceros* complex.—ten Hove (1994: 113).

Material examined. Kimberleys, Western Australia: 2 specimens, AM W21441, Condillac Island, 14°06'S 125°33'E, sand with scattered bommies, intertidal, 12 m, 16 Jul. 1988, st 54; 1 juvenile specimen, AM W21397, east side of Fenelon Island, 14°07'S 125°43'E, from anterior end of tube of *Serpula jukesii* tube, 6 m, st 64. 1 specimen, AM W21398, east side of Fenelon Island, 14°07'S 125°43'E, 18 Jul. 1988, st 64; 1 specimen without its tube, AM W21399, east side of Fenelon Island, 14°07'S 125°43'E, 18 Jul. 1988, st 64; 2 specimens, AM W202956, Lafontane Island, 14°10'S 125°47'E, 15 m, 19 Jul. 1988, st 68. 2 specimens, AM W21411, east Montalivet Island, 15°06'S 125°18'E, intertidal, 6 m, 15 Jul. 1988, st 50. 2 specimens without opercula (one without tube), AM W21403, Rob Roy Reef, 14°26'S 124°52'E, 14 Jul. 1988, st 49; 4 specimens without tubes, AM W202937, Lafontane Island, 14°10'S 125°47'E, 15 m, 19 Jul. 1988, st 68. 1 specimen, W202940, Coronation Island, 15°05'S 124°56'E, low tide, 13 Jul. 1988, st 33; 1 specimen without tube and incomplete posteriorly, AM W21425, south west corner of Lucas Island, 15°13'S 124°31'E, 30 m, 24 Jul. 1988, st 101. 1 specimen, AM W202953, Condillac Island, 14°06'S 125°33'E, sand with scattered bommies, intertidal, 16 Jul. 1988, st 54. 2 specimens, AM W202954, east side of Fenelon Island, 14°07'S 125°43'E, 6 m, 18 Jul. 1988, st 64. 2 specimens, AM W21440, Lafontane Island, 14°10'S 125°47'E, 15 m, 19 Jul. 1988, st 68; 19 specimens, AM W202962, Rob Roy Reef, 14°26'S 124°52'E, 14 Jul. 1988, st 49. 7 specimens, (2 without opercula), AM W21449, reef, north west of Buffon Island, 14°55'S 124°41'E, 20 m, 23 Jul. 1988, st 85; all coll. P.A. Hutchings.

Description

Measurements. Maximum external tube diameter in available specimens 4.0 mm; minimum 1.5 mm in a juvenile in AM W21441. Total length of larger worm in AM W21441, 16.1 mm; abdomen 8.9 mm long, 78 segments.

Tube. Mostly covered over by coral; difficult to remove without damage to external ridges. Colour in larger specimens usually white, with a light caramel coloured inner layer; both specimens from AM W202953 white, with a bluish-grey band along the median ridge, especially in their earlier formed parts; obtusely triangular in cross-section in older

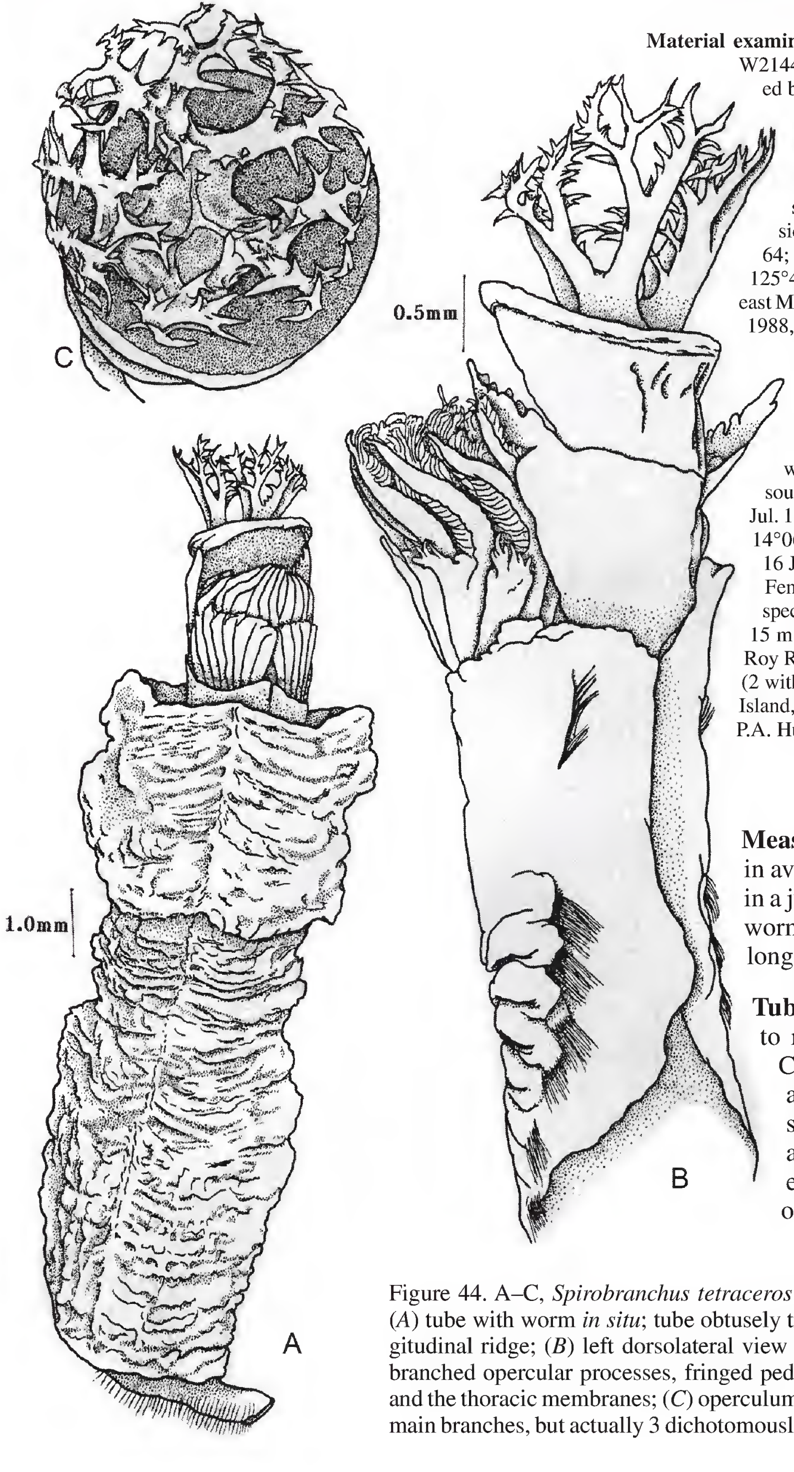

Figure 44. A–C, *Spirobranchus tetraceros* (Schmarda, 1861), specimen from AM W21438. (*A*) tube with worm *in situ*; tube obtusely triangular in cross-section, with a low median longitudinal ridge; (*B*) left dorsolateral view of anterior end of worm showing dichotomously branched opercular processes, fringed peduncular wings, fringed inter-radiolar membranes, and the thoracic membranes; (*C*) operculum viewed from anterior end; showing (apparently) 4 main branches, but actually 3 dichotomously branched processes arising from a common base.

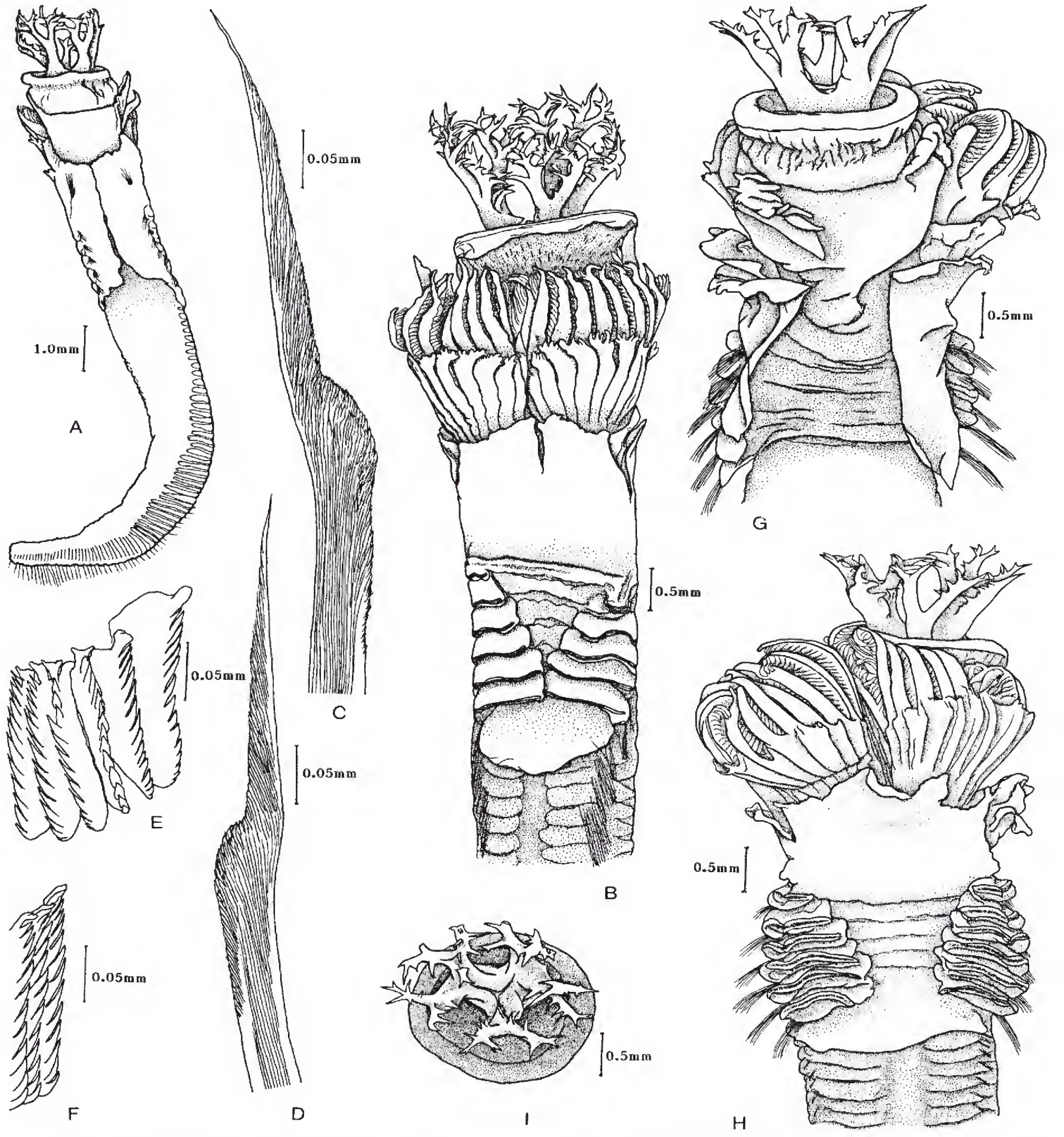

Figure 45. A–I, *Spirobranchus tetraceros* (Schmarda, 1861). A,B, a worm from AM W21441: (*A*) dorsal view of whole worm; (*B*) ventral view of anterior end of the latter worm; shows the branched horns, mottled ventral side of peduncle, fringed interbranchial membranes, pinnule-free radiolar tips, raised uncinal pads, the last two meeting mid-ventrally and the apron which is contracted into a triangular lobe, since the worm was fixed within its tube, and the long-shafted abdominal chaetae. C–F, chaetae from same specimen: (*C,D*) bayonet-shaped special collar chaetae; (*E,F*) thoracic uncini. G–I, a specimen from AM W21441: (*G*) dorsal view of anterior end, highly contracted, showing fringed opercular wings and fringed inter-radiolar membrane; (*H*) ventral view of anterior end showing inter-radiolar membranes, ventral lobe of collar, thoracic tori not meeting ventrally since the worm was evidently fixed outside its tube, the apron, and anterior abdominal chaetae with long shafts; (*I*) opercular spines viewed from the anterior end showing three main horns.

specimens with a single low median longitudinal ridge, and fine transverse growth markings extending laterally from it (Fig. 44A). Tube of juvenile from AM W21397 is white, with a high, wavy median ridge and a low dorsolateral ridge on either side of it (Fig. 46A,B); fine, shallow, transverse ridges present at irregular intervals, between longitudinal ridges and along flanks.

Worm. Colour (in alcohol): operculum and wings blue dorsally, and light blue with elongated blue specks ventrally; opercular plate white, its rim bright pink, as also are the tips of the horns. Although thorax and radioles in the juvenile specimen are colourless, they are bluish to purplish blue in the others. Basal two-thirds of branchial radioles, including inter-radiolar membrane, dark purplish blue; abdomen light purplish-blue anteriorly, gradually becomes colourless posteriorly. Operculum occurs on left side, no rudimentary operculum on right; opercular plate circular (Figs 44C, 45A,B,G–I, 46D,E,M,L). Distal end of operculum in a juvenile specimen is bulbous; its somewhat concave, circular plate bears apparently four, but really three, main branched horns arising from a common base, two of which

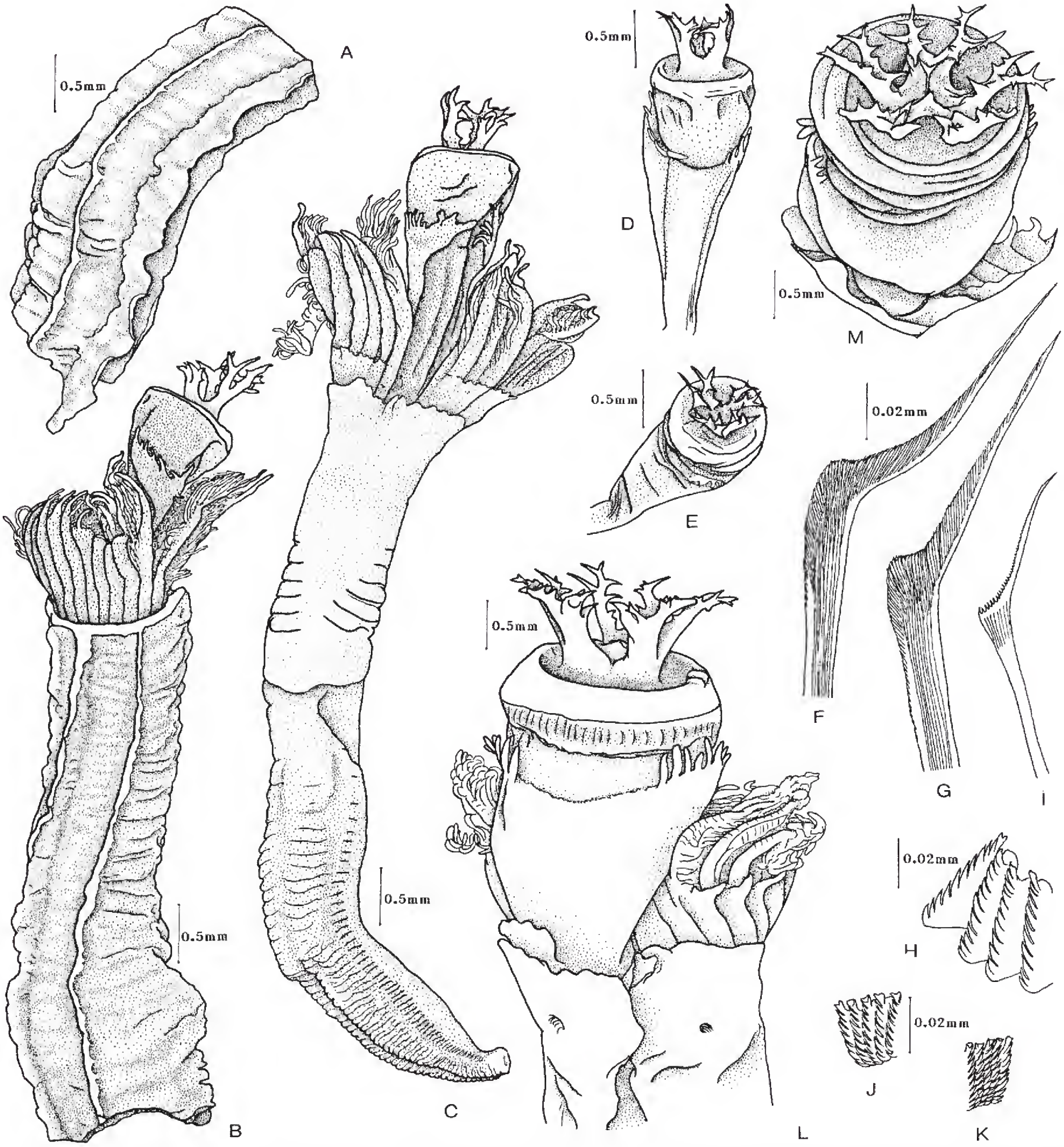

Figure 46. A–M, *Spirobranchus tetraceros* (Schmarda, 1861); A–K, specimen from AM W21397: (*A,B*) tube, showing high, wavy median longitudinal ridge and a low lateral ridge on either side of it; (*B*) tube with worm *in situ*; (*C*) worm viewed ventrolaterally; (*D,E*) operculum viewed dorsally and anterodorsally, respectively; (*F,G*) bayonet collar chaetae; (*H*) thoracic uncini; (*I*) distal part of an anterior abdominal neurochaetae; (*J*) anterior abdominal uncini; (*K*) posterior abdominal uncini. L,M, a specimen from AM W21449: (*L*) dorsal view of anterior end; (*M*) anterodorsal view of operculum, showing three main dichotomous branches, and a low peak at the centre, inter-radiolar membranes and fringed peduncular wings.

are dorsolateral, and the third ventral (Figs 44B, 45G,I, 46E,L,M). Opercula of 7 specimens from AM W21449, as well as those of others examined are similar and bear three main processes. In an older specimen, dorsolateral process is branched thrice, the ventral one twice. Peduncular wings fringed with digitate processes anteriorly (Figs 44A, 45G, 46B–D,L,M). In a specimen from AM W21449 there is a small peaked process, centrally, at the base of the three horns (Fig. 46L,M). Radioles arranged in a circle on each side (Fig. 45B,H), their numbers ranging from 11 pairs in the juvenile specimen described above to 28/29 radioles in a specimen from AM W202956 with a total length of 41.0 mm; their pinnule-free tips longer than the pinnules that precede them. Inter-radiolar membranes fringed, extending distally to about ⅓ to ½ length of radioles (Figs 44B, 45B,H, 46C,L). Prostomial ocelli not discernible, but a pair of light-caramel patches sometimes seen in the corresponding positions. Thoracic chaetigers number 7, apron present (Figs 45B,H, 46C). Uncinal tori in thorax of adults occur on conspicuously raised pads with the distances between corresponding pairs decreasing posteriorly, leaving a triangular area between them; 5th and 6th pairs may meet mid-ventrally, as in specimens fixed within their tubes (Fig. 45B), or may be separated when worms are fixed outside the tube (Fig. 45H). In juveniles uncinal tori do not occur on conspicuous pads (Fig. 46C).

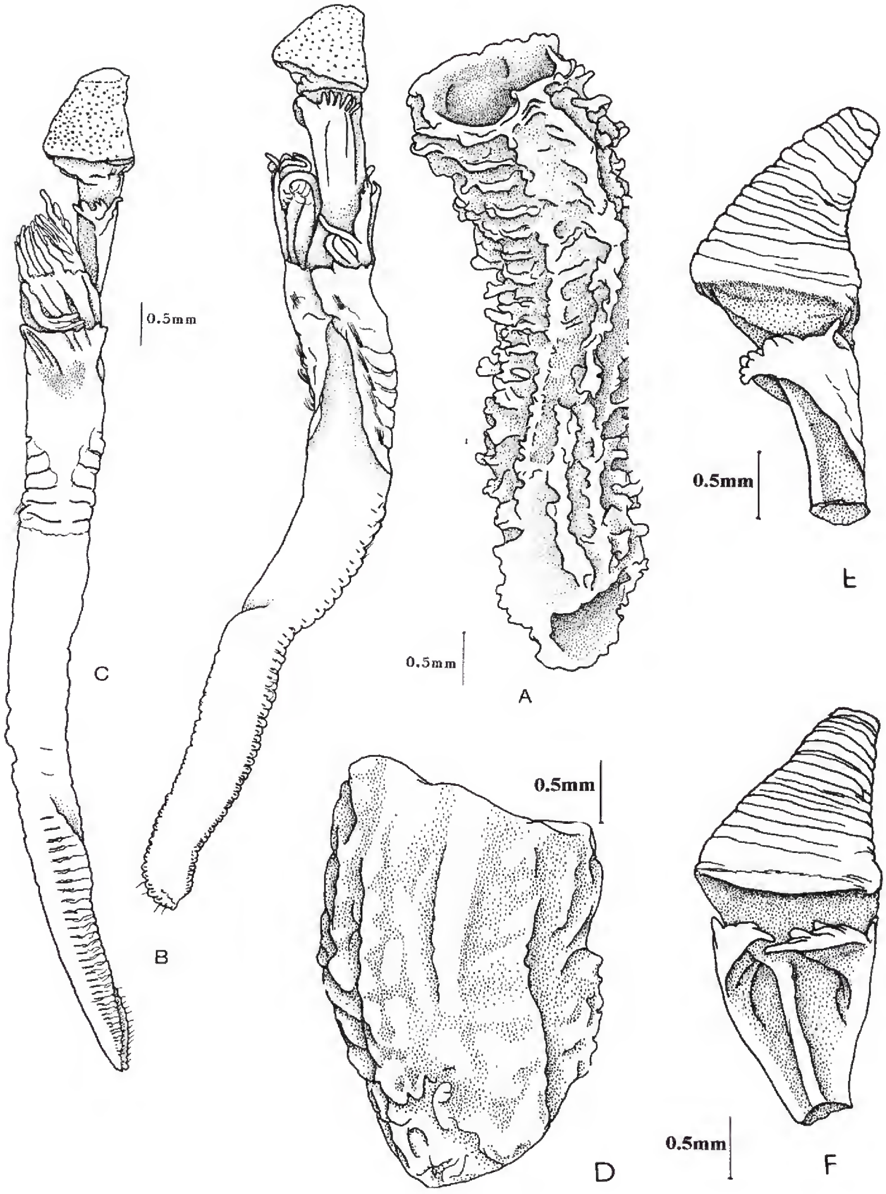

Figure 47. A–C, *Spirobranchus* sp. 1: two juveniles separated from AM W21432: (*A*) dorsal view of one of the specimens; (*B*) dorsal view of first specimen; (*C*) ventral view of second specimen. D–F, *Spirobranchus acuiconus* Pillai, 1960, from holotype BMNH 1959.4.14.4: (*D*) tube; (*E,F*) two views of operculum.

Chaetae. Special collar chaetae bayonet-shaped; a conspicuous squarish boss present; area of shaft preceding the boss as well as the boss serrated; an unserrated notch absent between the latter and blade (Figs 45C,D, 46F,G), the latter two from a juvenile specimen. Thoracic and abdominal uncini saw-shaped, with a single row of teeth; ending anteriorly in a gouged process. Thoracic uncini bear about 10–12 teeth (Figs 45E,F, 46H), latter in a juvenile specimen; anterior abdominal uncini bear about 8 or 9 teeth (Fig. 46J); may increase to about 13 in posterior segments (Fig. 46K). Abdominal neurochaetae possess long shafts throughout the entire length of the abdomen (Fig. 45B); their flattened trumpet-shaped distal ends asymmetrical, with one side drawn into a tapering process (Fig. 46I).

Remarks. From the distribution provided by ten Hove (1970a), it appears that a single "*tetraceros*-type species", *S. tetraceros*, occurs from the Caribbean region to the Indo-Pacific, which would also make it a very ancient species. According to ten Hove (1970: figs 7, 8), there is overlap in the opercular structure between samples from Curaçao (Spaanse Baai) and those from the Indo-West Pacific.

However, *Spirobranchus tetraceros* was originally described from New South Wales as *Pomatoceros tetraceros* by Schmarda, 1861. As stated by Smith (1985, unpublished thesis) and ten Hove (1994), collections of *Spirobranchus* *tetraceros* identified by workers in the past appear to consist of a complex of species, and detailed studies of different populations are needed to sort out their identities. Nevertheless, the Kimberleys specimens agree with the description of *Spirobranchus tetraceros* (Schmarda, 1861), and are, therefore, assigned to it.

Ten Hove (1970a) believes that differences in opercula observed in collections from a particular area could well be variations within the same species. Examples are the conical operculum of a specimen from Spaanse Water, Curaçao, and a similar one from Bahrein, shown in Figs 6 and 15, respectively (ten Hove, 1970a). Similar variations have been reported in populations from the Indo-West Pacific, e.g., *Spirobranchus semperi* var. *acroceros* Willey, Pillai (1960: 18, fig. 7A–C), *Spirobranchus tricornigerus* (Grube), Pillai (1960: 20, fig. 7D–G), and *Spirobranchus tricornis* (Mörch), Straughan (1967: 244, fig. 14b–d).

Trinomial nomenclature was used in some instances to designate specimens/populations that were different from a nominal species with regard to certain characters, as varieties of that species, e.g., *S. tricornigerus* Grube, 1878 var. *racemosus* Pillai (1971) from Sri Lanka, and *S. tricornigerus decoratus* Imajima (1982) from Micronesia. Imajima and ten Hove (1984) recognized them as being identical and named them as a distinct species *Spirobranchus decoratus* Imajima, 1982. Both varieties have the following common characteristics: tube pink on a white background, triangular in cross-section, with a high median longitudinal ridge, and 5 longitudinal rows of pits; operculum bears three main branched processes, compact and directed parallel to the plane of the opercular disc rather than away from it. Peduncular wings fringed; branchial radioles arranged in a circle on each side; inter-radiolar membranes present. Special collar chaetae bayonet-shaped; thoracic uncini and anterior abdominal uncini have about 12 teeth.

From descriptions of the species which follow, it will be seen that the opercular horns and opercular plate in certain *Spirobranchus* collections/populations from different Indo-West Pacific locations are so superficially similar to those of *S. tetraceros* that they can, upon cursory examination, be assigned to the "*Spirobranchus tetraceros*-complex".

However, more detailed comparisons between samples or populations, and of character combinations, including tube form, and colour (differences in the latter, presumably having a biochemical basis), structure of opercular processes and chaetae, could reveal distinct species of *Spirobranchus*. For instance, Smith (unpublished thesis, 1985) describes three unnamed species belonging to the *S. tetraceros* group, species A, B, and C, from NSW and Queensland. Moreover, ten Hove (1994: 113) states: "in 1970, I united various nominal taxa from circumtropical origin in a single species: *S. tetraceros*. Nowadays I realize that this has been an oversimplification, the taxon *tetraceros* probably contains a number of species … "

It would, therefore, appear more useful, in the long run, to acknowledge that certain collections had been unidentifiable for one reason or another, and retain them as un-named taxa, while awaiting the results of further research, rather than designate them as belonging to currently unrecognized taxonomic categories, such as "… complexes" or "… groups".

Spirobranchus sp. 2 (juveniles)

Fig. 47A,C

Material examined. Kimberleys, Western Australia; 3 specimens, growing on and thinly covered over by easily removable coral, AM W21432, east of Montalivet Island, 15°06'S 125°18'E, intertidal, 6 m, 16 Jul. 1988, st 50; coll. P.A. Hutchings.

Description

Measurements. Maximum measurements follows: tube diameter 1.5 mm, total length of worm 8.7 mm, width of thorax 0.9 mm, length of operculum and peduncle 8.7 mm, operculum 1.0 mm, abdomen 0.9 mm.

Tube. Colour faintly pink. Three longitudinal ridges present dorsally, and one along each flank, as well as narrow transverse ridges (Fig. 47A). Median longitudinal ridge high and wavy; those on either side of it and along the flanks are low. Outlines of the longitudinal ridges irregular due to the presence of short digitate processes extending from them, apparently freshly overlaid with coral.

Worm. Operculum on the left side; consists of a conical, pitted, calcareous cap; distal end of latter slanted, blunt and lacks processes (Fig. 47B,C); peduncular wings fringed anteriorly. Maximum number of radioles counted 10 per side; a fringed inter-radiolar membrane present. Prostomial ocelli not discernible, thoracic chaetigers number 7, an apron present; highest number of abdominal segments among the three specimens, 55. Neurochaetae with long shafts present throughout the abdomen, the last 25–30 segments with longer and more slender chaetae.

Remarks. The tube form and colour in the above juveniles are different from those of juvenile *S. tetraceros*. While those of the above juveniles are pink, those of *S. tetraceros* are white, possess a high sinuous median longitudinal ridge and a low one along each flank (Fig. 46A,B), but lacks the fine digitate processes seen in the present juveniles, the latter perhaps formed by new coral encrustation. The smallest available juvenile operculum of *S. tetraceros* is shown in Fig. 46B–E. As seen from the scales against the figures, its opercular plate and horns are quite small, but the plate is not conical as in the present juveniles. In the present state of our knowledge of the ontogeny of the various species of *Spirobranchus*, it is difficult to assign the present juveniles with conical opercula (Fig. 47B,C) to any particular species.

Similar specimens were described by Pillai (1960: 21–22, fig. 8F–I), as a new species, *Conopomatus sectoconus*, under a new genus *Conopomatus*, which also included *C. acuiconus*. Ten Hove (1970) correctly synonymized *Conopomatus* with *Spirobranchus*, while considering the operculum of *C. sectoconus* to be similar to that he described as the juvenile condition of the *S. tetraceros* "complex". Further studies would be needed to confirm whether the juvenile *Spirobranchus* sp. described above, those described b Pillai (1970) and ten Hove (1970) occur in *Spirobranchus tetraceros* (Schmarda, 1861).

Section 2

Descriptions and comparisons with some collections of *Spirobranchus* from other locations in Australia and the Indo-West Pacific Oceans

Spirobranchus acuiconus (Pillai, 1960)

Fig. 47D–F

Conopomatus acuiconus Pillai, 1960: 21–23, fig. 8A–E.
Spirobranchus acuiconus (Pillai, 1960).—ten Hove (1970: 5).

Type material. HOLOTYPE, *Conopomatus acuiconus* Pillai, 1960, BMNH 1959.4.14.4, Pearl Banks, Sri Lanka, coll. T.G. Pillai; re-examined during present study.

Description

Measurements. Tube in 4 fragments, white and bears a low, smooth medial longitudinal ridge and a lateral longitudinal ridge along the edge of a flattened part of tube on either side of the median longitudinal ridge (Fig. 37A). Total length of worm is 11. 4 mm; width of thorax 1.0 mm; length of operculum and peduncle 3.2 mm; length of operculum alone, 1.6 mm. Number of radioles: 12 plus operculum on left and 14 radioles on the right. Operculum has about 13 transverse annuli, superficially certain species of *Vermiliopsis* (Fig. 37B,C). However, it is calcareous, its peduncle winged, and wings fringed, unlike in *Vermiliopsis* in which the operculum is chitinous, and its peduncle wingless.

Remarks. Ten Hove (1970: 5) correctly synonymized *Conopomatus sectoconus* Pillai, 1960, with *Spirobranchus tetraceros*. However, there is no evidence as yet for *Spirobranchus acuiconus* (Pillai, 1960), to be synonymized with *S tetraceros*. A transversely annulated calcareous operculum lacking opercular horns or vestiges, as in *S. acuiconus*, has not been recorded in individuals belonging to populations of *S. tetraceros* in the Indo-Pacific area. It would, therefore, be useful to keep *S. acuiconus* distinct until evidence to the contrary emerges through future studies.

Spirobranchus arabicus (Monro, 1937)

Fig. 48A–H

Spirobranchus giganteus var. *arabica* Monro, 1937: 317.
Spirobranchus arabica.—Hartman (1959: 599).

Material examined. SYNTYPES: 6 specimens with their tubes, BMNH 1937.9.2.545–548, Arabian south coast, depth 38 m, 18°03'30"N 57°02'30"E, Murray Expedition, Station 45, 29 March 1933; labelled syntypes of *Spirobranchus giganteus* var. *arabica* Monro.

Description

Measurements. Based on three larger tubes, maximum external diameter, including the median longitudinal ridge, 5.6 mm; total length of longest worm, 39.0 mm; lengths of operculum and peduncle 9.0 mm, thorax 7.0 mm, abdomen 23.0 mm; number of abdominal segments 86; number of radioles, 34 on each side. Longest operculum and widest thorax in another specimen: 2.2 mm and 3.6 mm, respectively.

Tube. Overall colour, light to bright pink or pinkish red; one tube brownish mauve. Isolated or small clusters of granules of tube material occur irregularly on the surface (Fig. 48A). Anterior end of the tube may be peristome-like with short ridge-like extensions strengthening it. A high, wavy, median longitudinal ridge present, more or less continuous along its entire length in some tubes (Fig. 48A), or naturally interrupted or broken off in places in others. Very faint transverse ridges are present throughout, with alternating thin bands of light and dark pink coinciding with them and the grooves in between. Transverse ridges may be raised along the flank (Fig. 48A) to form a faint single or double longitudinal ridge, with a narrow, shallow longitudinal groove between them in the latter.

Worm. Operculum on left side, no rudimentary operculum; adult opercular plate dome-shaped (Fig. 48C) to somewhat convex (Fig. 48B), with up to about 4 processes of variable length which may bear short lateral processes (Fig. 48B). All older specimens have a colonial coelenterate (Hydroida: *Hydractiniidae*) growing on the operculum (Fig. 48B). The horny anastomozing perisarc of the latter is very closely bonded with the opercular disk and horns, and is very difficult to remove without damaging the latter. Opercular wings fringed anteriorly. A juvenile operculum (Fig. 48D) has a short conical cap with a dorsally directed peak and lacks processes as well as the epizoic coelenterate. Colour of the radioles in alcohol light to dark blue; up to 34 radioles per side counted, arranged in a circle, their pinnule-free tips are moderately long and much thicker than the pinnules. Inter-radiolar membranes wide and pleated between radioles, but are not fringed (Fig. 48B); apron present.

Chaetae. Bayonet collar chaetae (Fig. 48E,F) similar to those usually encountered in the larger species of the genus in having a squarish boss; moderately long serrations present along blade; unserrated notch absent. Compared to most other species with similar bayonet chaetae, a long part of chaetal shaft itself is serrated distally, the latter almost equal to the length of the blade. Thorax uncini (Fig. 48G) bear 13 teeth in a single row and an anterior gouged process; anterior and posterior abdominal uncini similar (Figs 48H), bearing about 9 and 11 teeth, respectively, in addition to the anterior gouged process; long-shafted abdominal chaetae present throughout the abdomen.

Remarks. The new species, *Spirobranchus arabicus*, is similar to *S. tetraceros* from the Kimberleys with regard to the circular opercular plate bearing branched horns, the arrangement of radioles in a circle, bayonet collar chaetae having a prominent squarish boss and thoracic uncini bearing about a dozen teeth. Ten Hove (1970: 3) synonymized the present species with *S. tetraceros*. However, there are important differences between them. The tube in *S. arabicus* is bright pink to pinkish-red. It is circular in cross-section in older specimens, and bears a high, wavy, fin-like median longitudinal ridge (Fig. 48A). Inter-radiolar membranes are

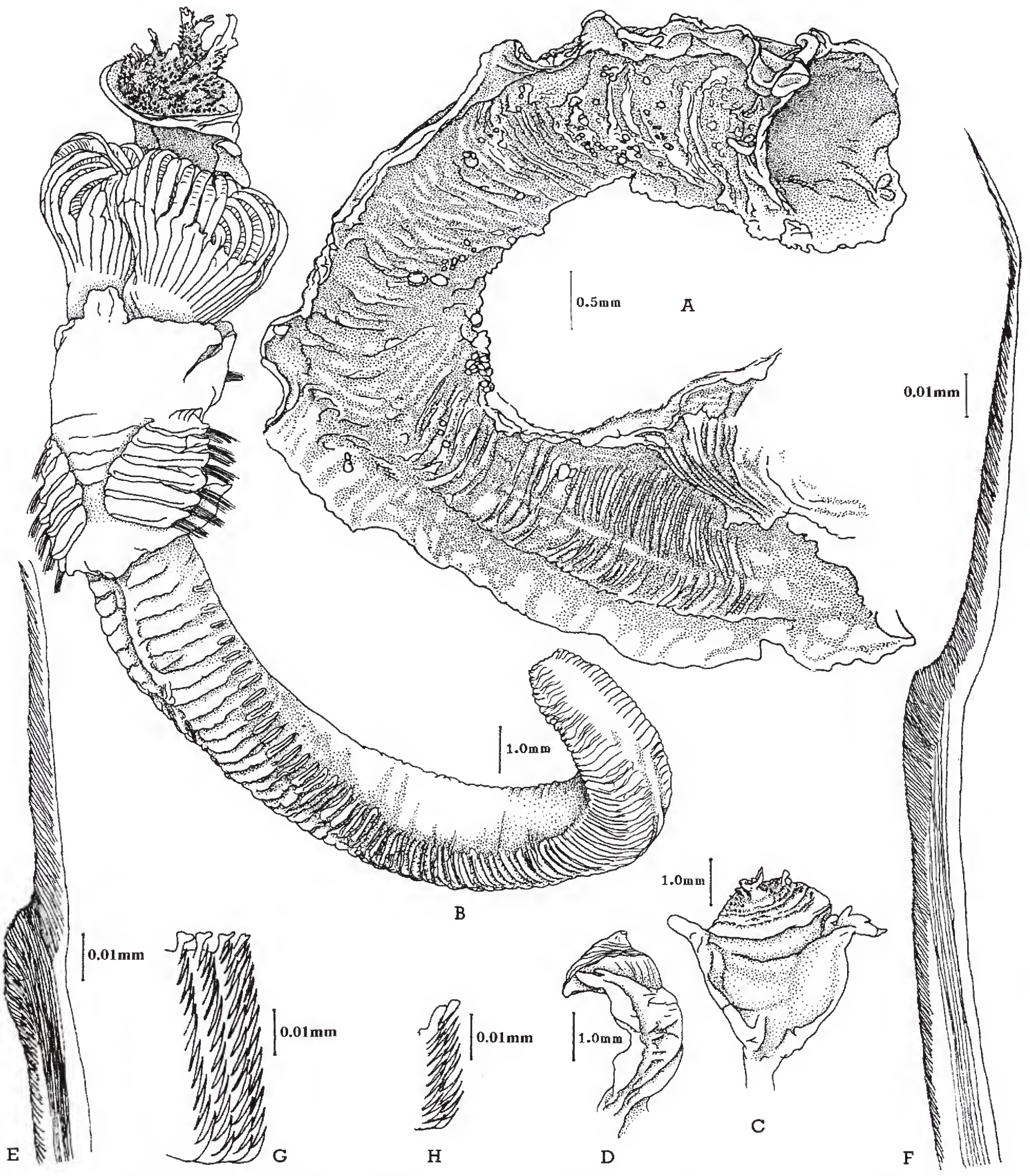

Figure 48. A–H, *Spirobranchus arabicus* (Monro, 1937): (*A*) tube showing the high median longitudinal ridge with fin-shaped sections. The latter may be high and long as in the posterior part of the tube figured, or consist of smaller low, fin-shaped processes as seen in its anterior part; (*B*) entire worm, showing the ventral side of the thorax; (*C*) dorsal view of the operculum of an older specimen; (*D*) dorsolateral view of the operculum of a juvenile; (*E,F*) bayonet-shaped collar chaetae; (*G*) thoracic uncini; (*H*) posterior abdominal uncini.

unfringed. In contrast, the older tubes of the *S. tetraceros* from the Kimberleys are white, obtusely triangular in cross-section, and bear a very low, median longitudinal ridge (Fig. 44A). Furthermore, its inter-radiolar membranes are fringed unlike in the present species.

Spirobranchus sp. 3

Fig. 49A–D

Material examined. BMNH 1959.10.28A, 1 specimen lacking its tube and part of its abdomen, Eden, NSW, Australia, collected and presented by E.W. and P. Knight-Jones.

Description

Measurements. Width of thorax 1.8 mm, length of operculum & peduncle 4.0 mm, length of operculum 2.5 mm, and diameter of operculum 2.0 mm.

Tube. Missing.

Worm. Operculum on left side, no rudimentary operculum on the right; 20 radioles on each side, some on the left appear to have been in a state of regeneration. Operculum (Fig. 49B,C) ends distally in a simple, somewhat concave, calcareous plate, with a narrow transparent rim, lacks processes. Peduncular wings unfringed, although the tip of wing of left side is aberrantly bifid (Fig. 49C). Radioles arranged in a circle on each side; inter-radiolar membranes unfringed (Fig. 49A). Pinnule-free tips of radioles are slightly thicker than and about as long as the longest pinnules. Thorax with 7 chaetigers; gaps between corresponding pairs of thoracic uncinal tori decrease towards posterior end of thorax leaving an inverted triangular area between them ventrally (Fig. 49A), as in certain other species of the genus. Uncinal tori: borne on flap-like extensions of thoracic segments; apron present (Fig. 49A).

Chaetae. Special collar chaetae different from bayonet-shaped chaetae often associated with *Spirobranchus* in lacking a squarish boss; however, a bend towards the smooth side of the shaft indicates transition from the serrated part of the chaetal shaft ends to the chaetal blade (Fig. 49D); serrations along blade continue to a short distance from its tip (Fig. 49D). Thoracic uncini saw-shaped; bear a row of about 10–11 teeth and an anterior gouged process; anterior and posterior abdominal uncini similar and bear about 9 teeth. Abdominal chaetae possess long shafts projecting beyond abdominal wall; one side of distal end drawn out into a tapered process.

Remarks. Although *Spirobranchus* sp. 2 is superficially similar to *S. maldivensis* Pixell, 1913, and *Spirobranchus kraussii* Baird, 1861 (= *Pomatoleios crosslandi* Pixell, 1913) in possessing a circular opercular plate lacking opercular processes, they differ amongst themselves as follows. The opercular plate of *S. maldivensis* (Fig. 52E), bears concentric rings of increasing diameter from the centre outwards, which are absent in *S.* sp. 3 (Fig. 49B) and *S. kraussii* (Fig. 49E). The opercular rim is conspicuous and translucent in *S.* sp. 2 (Fig. 52B), thick and non-translucent in *S. kraussii*, it is inconspicuous in *S. maldivensis* (Fig. 52C,D). The special collar chaetae of *S.* sp. 3 lack a squarish boss (Fig. 49D), whereas those of *S. maldivensis* possess a squarish boss (Fig. 52G), although not as prominent as in certain other species of *Spirobranchus*, e.g., *S. arabicus* n.sp. (Fig. 48E,F). While special collar chaetae are absent in the adults of *S. kraussii*, they are sometimes present in juveniles; when present, they are almost capillairies (Fig. 49G). The thoracic uncinal tori in *S.* sp. 3 are borne on raised flaps (Fig. 49A), unlike in *S. maldivensis* (Fig. 52C,D,F) and *S. kraussii* (Fig. 49E,F).

Unfortunately, the tube of the single specimen of *S.* sp. 3 is missing; this needs further investigation during future studies. Meanwhile, it is worth noting the tube and form in the type specimens and additional material of *S. maldivensis* described in this account (Fig. 52B).

Spirobranchus elatensis n.sp.

Fig. 50A–F

Type material. HOLOTYPE, BMNH 1995.1659, with its tube, Akaba, Gulf of Elat, found growing on a sponge, coll. by U.N. Safriel in 1958, determined as *Spirobranchus tetraceros* (Schmarda) by M.N. Ben-Eliahu.

Description

Measurements. Maximum height of tube, including median longitudinal ridge, 4.5 mm; 3.5 mm excluding the latter; maximum width of tube 4.7 mm. Worm with posterior part of its abdomen broken off; posterior ends of two worms present in vial. Length of operculum and peduncle 4.7 mm, length of operculum 2.2 mm, diameter of opercular plate 2.5 mm. Radioles number 19 plus operculum on the left, and 19 on the right.

Tube. White, wide anteriorly and narrows abruptly towards posterior end (Fig. 50A,B); trapezoidal in cross-sectional outline, has a high, wavy, MLR (Fig. 50B), which is thick when viewed from above (Fig. 50A), projects conspicuously over aperture (Fig. 50A,B). Although apparently nearly flat on either side of MLR, actually gently sloping laterally (Fig. 50B); along on each side of the lateral edge of this almost flattened area, is an LLR. Smooth faint transversely arranged grooves and ridges present between median and lateral longitudinal ridge of each side (Fig. 50A,B). Longitudinal rows of foramina: absent.

Worm. Operculum on left side, rudimentary operculum absent; opercular shape conical; its apex curved dorsally and bears vestiges of three opercular horns (Fig. 50C,D); latter dichotomously branched and ending in a few short transparent spines. Granular deposits of calcareous material present along sides of operculum are (Fig. 50C). Peduncular wings fringed (Fig. 50D). Branchial radioles arranged in a circle on each side; their pinnule-free tips conspicuous and about 2½ times as long as the pinnules. Thorax consists of 7 chaetigers.

Chaetae. Special collar chaetae characterized with following: boss square and papillate (Fig. 50E,F). Serrations present all around distal part of the chaetal shaft (i.e., dorsally, laterally and ventrally), unlike in the other species of *Spirobranchus* dealt with in this account, where they are present only along the side of the shaft opposite to that of the blade and partly along sides of the latter. Ratio of length of blade to that of the serrated part of chaetal

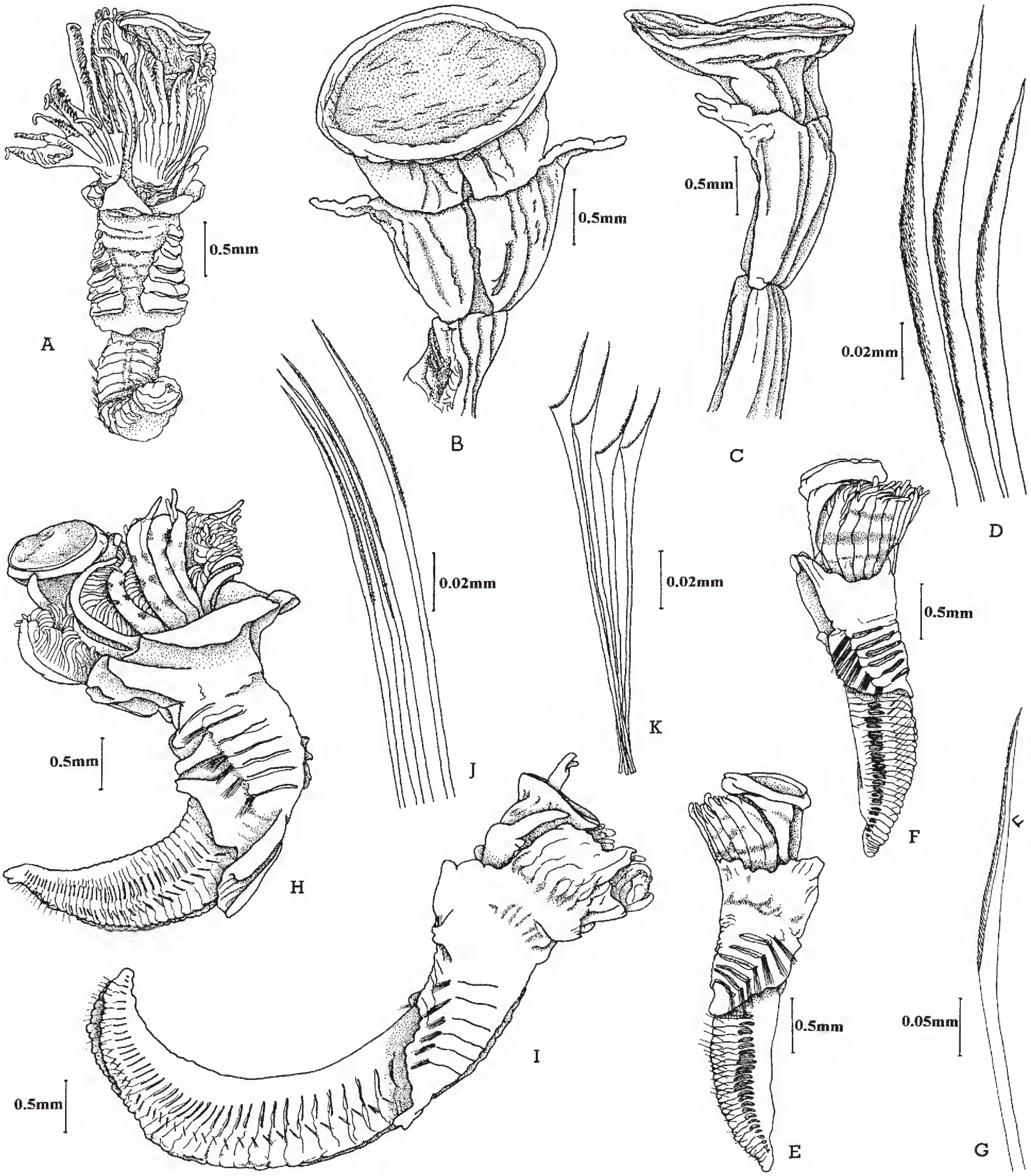

Figure 49. A–D, from *Spirobranchus* sp. 3, BMNH 1959.10.19.28, specimen collected by E.W. & P. Knight Jones from Eden, NSW, Australia: (*A*) ventral view of anterior part of worm; (*B,C*) anterodorsal and lateral views, respectively, of the operculum; (*D*) special collar chaetae; their chaetal shafts merge gradually with their blades, a boss not recognizable between them, the bend in the chaeta indicating the approximate position between them. E–G, *Spirobranchus kraussii* (Baird, 1864), from a small juvenile in a sample collected by David George, Reg. No: NHM, ANEA 2009.23, from Abu Dhabi: (*E*) shows 7 thoracic chaetigers on the right side; (*F*) shows absence of a collar fascicle on the left side, i.e. only 6 chaetigers on the left; (*G*) a collar chaeta from the right side where it occurs. It lacks a serrated shaft and boss, and is indistinguishable from the other thoracic notochaetae; (*H–K*), *Spirobranchus triqueter* (Linnaeus, 1767) (= *Pomatoceros triqueter*) two juvenile from British waters specimens for comparison, both show abdominal neurochaetae with conspicuously long shafts protruding from the abdomen, besides variations in the operculum; (J) chaetae from the collar fascicle: their shafts lack serrations distally as well as a boss; (K) abdominal neurochaetae: one side of its flattened trumpet-shaped distal ends in a tapered process as in the other species of *Spirobranchus*.

shaft plus boss is about 1.27: 1.0. Thoracic and anterior abdominal uncini: saw-shaped, former bearing 8–11 teeth, and latter 8, in addition to the anterior gouged process. Abdominal chaetae possessing conspicuous long shafts projecting from the body wall present from the beginning of the abdomen.

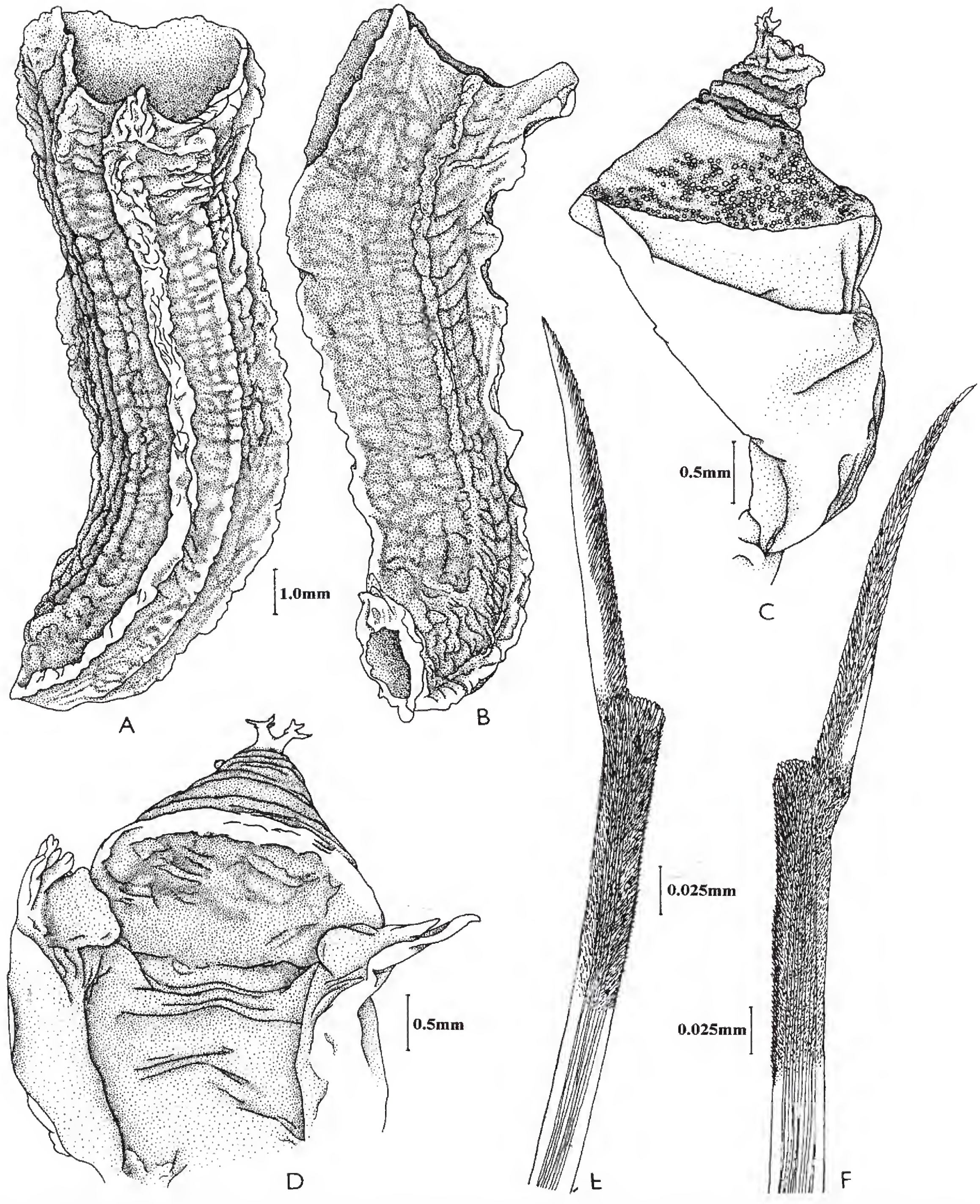

Figure 50. A–F, *Spirobranchus elatensis* n.sp. (*A*) tube viewed from above. It increases in width quickly towards its anterior end. There is an apparently flattened area on either side of the median longitudinal ridge, along the edge of which is a lateral longitudinal ridge; (*B*) lateral view of the same tube. It shows that the apparently flattened area on either dies of the median longitudinal ridge is actually inclined towards the lateral longitudinal ridge. Fin-like extensions occur along the median longitudinal ridge, the highest one being at the aperture; (*C*) left lateral view of the operculum and peduncle; (*D*) the operculum and peduncle viewed from the ventral side, showing fringed peduncular wings; (*E,F*) bayonet-shaped collar chaetae; note the square boss, serrations all round the distal end of the shaft, and the blade that is longer than the serrated distal end of the shaft plus the boss.

Remarks. *Spirobranchus elatensis* n.sp. is superficially similar to certain other taxa described in the past from the Indo-Pacific in possessing a dome-shaped to somewhat conical opercular plate with reduced horns borne at its apex. They are *S. semperi* var. *acroceros* Willey (Pillai, 1960: 18, fig. 7A–C); *S. tricornigerus* (Grube), Pillai (1960: 20, fig. 7D–G), *Spirobranchus tricornis* (Mörch), Straughan (1967: 244, fig. 14b–d), and *S. semperi* var. *acroceros* Willey, Mohammad (1971: 300), which were synonymized with *S. tetraceros* by ten Hove (1970: 3–5).

Ten Hove (1970: 6, figs 1, 2, 15 & 16) also describes a specimen from Bahrein with a conical operculum and vestigial horns. Its tube is reddish in colour, triangular in cross-section, and possesses a prominent ridge, which projects over the aperture. However, *S. elatensis* differs from the latter and *S. tetraceros* reported from the Indo-Pacific with regard to the following characters. Its tube is white, trapezoidal in cross-section and bears a high, thick, wavy median longitudinal ridge, the latter with fin-like sections at intervals and projecting forwards over the aperture. It also bears a pair of lateral longitudinal ridges, each along the edge of a flattened part of the tube on either side of the median longitudinal ridge. Furthermore, the special collar chaetae of *S. elatensis* are quite characteristic, in possessing a square, papillate boss, and the distal part of its chaetal shaft being conspicuously serrated all round (Fig. 50E,F). Indeed, they are quite unlike those of the other species of *Spirobranchus* dealt with in this account as well as in the specimen from Bahrein described by ten Hove (1970: fig. 18).

Spirobranchus tetraceros differs from *S. elatensis* as follows. Its tube is white to cream or bluish, its adult tubes are obtusely triangular in cross-section and its thin, low median longitudinal ridge is comparatively inconspicuous (Fig. 44A). Its opercular horns are comparatively long and well developed. The boss of its special collar chaetae is not as square and papillate all around the distal part of the chaetal shaft, as in *S. elatensis*, but serrated only ventrally and ventrolaterally (Fig. 45C,D).

Etymology. Named after the type locality, Elat, Gulf of Aqaba, Red Sea.

Spirobranchus kraussii (Baird, 1865)

Fig. 49E–G

Placostegus cariniferus var. *kraussii* Baird, 1865: 14.
Pomatoleios crosslandi.—Pixell (1913: 85–86, fig. 10a–d).
Pomatoleios crossland Pixell.—Hartman (1959: 587).
Pomatoleios crosslandi.—Pillai (1960: 15, fig. 6A–D).
Pomatoleios kraussii.—Uchida (1978: 33), Pillai (1971: 98), Mohammad (1971: 300), Straughan (1967: 235), Ishaq & Mustaquim (1996: 172–174, fig. 7).
Pomatoleios kraussii var. *manilensis*.—Pillai (1965: 169, fig. 22H).

Material examined. *Pomatoleios kraussii* collected from Dhafra Beach, Jebel Dhanna, Abu Dhabi in 1996 by Dr J. David George, Natural History Museum London. Registration No: NHM ANEA 2009.23.

Description

Measurements. Total lengths of larger worms up to about 23.0 mm. One juvenile worm has a total length of 4.0 mm.

Tube. White, with a pair of longitudinal ridges, a tongue-shaped extension over the aperture and several growth markings.

Worm. Colour of anterior part of body, especially operculum, radioles and thorax, blue in in alcohol-preserved material. Opercular insertion: in position of second radiole of left side; opercular plate circular, with a non-transparent rim, and lacks processes (Fig. 49E,F). Radioles arranged in a circle on each side; inter-radiolar membranes present; apron present.

Chaetae. Collar chaetal fascicles: absent in adults. A juvenile specimen has 7 thoracic chaetigers on the left (Fig. 49E), and 6 on the right (Fig. 49F). Collar chaetae of juvenile lack a boss; consist of shaft and blade (Fig. 49G). Abdominal chaetae with long shafts present throughout abdomen (Fig. 49E,F); their flattened, trumpet-shaped, distal ends have one side drawn out into a tapering process.

Remarks. The total lengths of Ishaq and Mustaquim's specimens (1996: 174) from Manora, Karachi Coast, Pakistan, ranged from 5.0–25.0 mm.

For a discussion on the synonymy of *Pomatoleios* and *Spirobranchus* see earlier discussion in the present paper. As regards special collar chaetae their reduction is more than in the preceding species to to the extent of their lacking even a trace of a boss, consisting merely of a shaft and blade (Fig. 49G), and being indistinguishable from the bladed notochaetae of the remaining thoracic chaetigers.

Spirobranchus sp. 4

Fig. 51A–G

Spirobranchus semperi.—Mohammad (1971: 300); non Mörch, 1861.

Type material. Four specimens, without tubes, Kuwait, Arabian Gulf, BMNH 1969.256, coll. and determined by M.B.M. Mohammad as *S. semperi* Mörch, 1861; as *S. tetraceros* (Schmarda, 1861) sensu ten Hove, 1970, according to a note in the jar by H. Zibrowius in 1972.

Description

Measurements. Total lengths of the four specimens range from 11.6–23.6 mm; thoracic widths, from 1.9–2.5 mm; total lengths of opercula, including opercular spines, opercular plate, and peduncle: 1.9–3.6 mm; diameters of opercular plates: 1.5–2.5 mm. abdominal lengths, 7.3–16.0 mm. Numbers of branchial radioles range from 11 plus operculum on left and 12 on right, to 23 plus operculum on left and 22 on right; number of abdominal segments, 5–80.

Tube. Missing in all specimens. Mohammad (1971: 300) does not describe them, and provides only a note on occurrence of the in Kuwait and the world distribution.

Worm. An easily removable epizoic bryozoan was found on the bases of opercular processes of the three specimens (Fig. 51A). Colour of opercular processes translucent white, their spines transparent white. Operculum on left side, no rudimentary operculum; opercular plate circular, slightly dorsoventrally oval; bears three main processes, each with two dichotomies in 3 specimens (Fig. 51B–D); in one specimen, however, dorsolateral spines are branched thrice. A single medial spine is located at or below the second dichotomy, followed distally by one, two, or three along each branch (Fig. 51C). Peduncular wings fringed, with a double row of papillae (Fig. 51A,C,E). Radioles transparent and colourless, conspicuously transversely wrinkled (Fig. 51B,D), end in pinnule-free tips, ⅓ to 1½ times as long as longest pinnules. Maximum number of radioles observed on each side 23, arranged in a circle; inter-radiolar membranes fringed (Figs 51B,D). Thorax consists of 7 chaetigers; apron present.

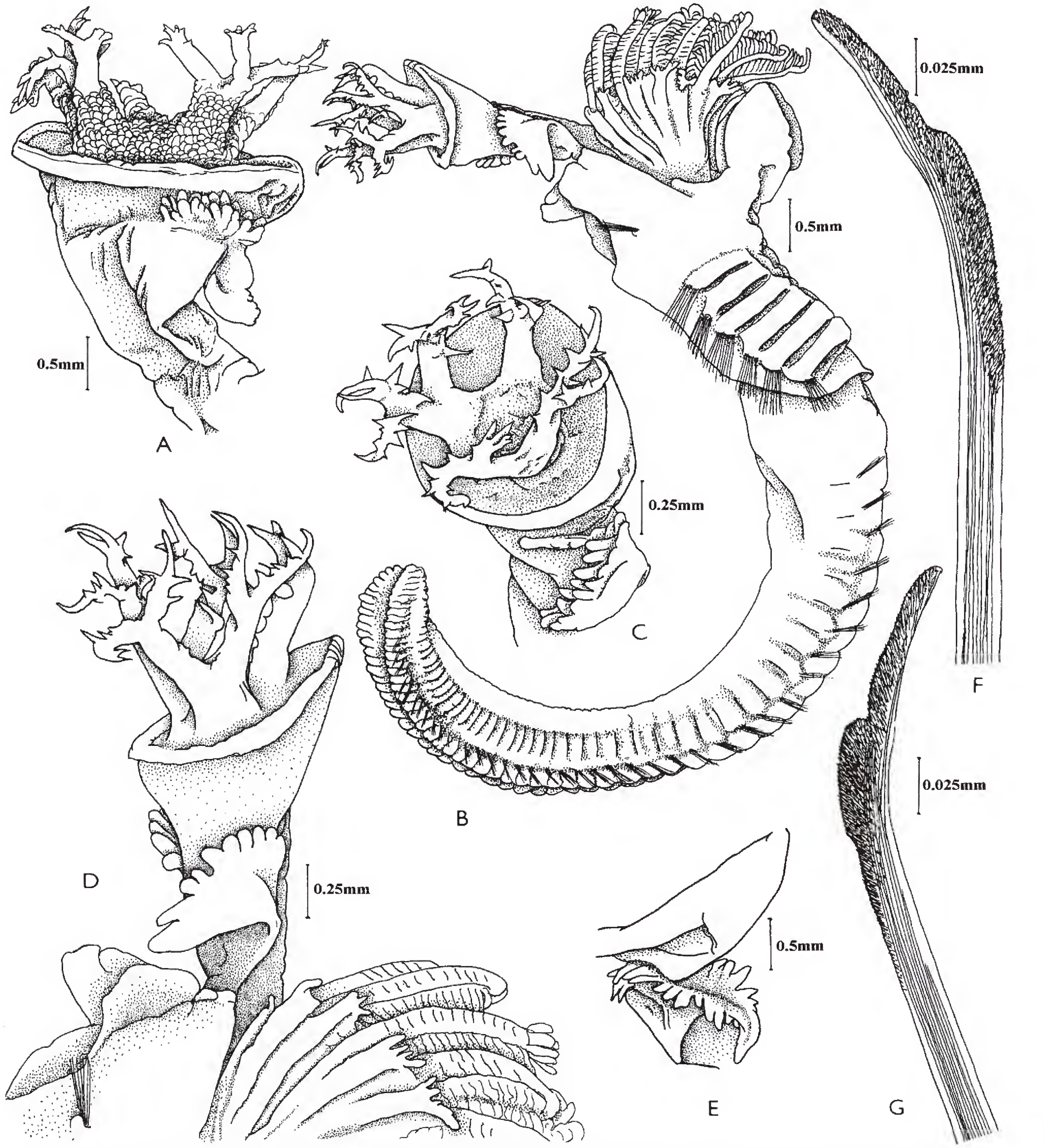

Figure 51. A–G, *Spirobranchus* sp. 4: BMNH 1969.256. (*A*) dorsal view of the operculum a specimen, showing the double row of numerous papillae on the peduncular wing, and a bryozoan on the base of the opercular horns; (*B*) another specimen, the whole worm. The opercular plate is somewhat asymmetrical in this specimen. The inter-radiolar membranes are fringed, and the abdominal neurochaetae possess long shafts projecting beyond the abdominal wall; (*C*) another view of the operculum of the worm figured in B. Note that there are only two main dichotomies, the single long spine curved towards the centre of the group of horns, and the double row of numerous papillae along the peduncular wing; (*D*) another view of the same operculum of specimen figured in B. Note the somewhat elliptical opercular plate, the fringed peduncular wings, and the fringed inter-radiolar membranes; (*E*) a peduncular wing showing the double row of papillae; (*F,G*) bayonet chaetae that have been worn out; the former is worn out at its tip, and the latter, in the serrated part of the shaft preceding the boss.

Chaetae. Older bayonet-shaped special collar chaetae may possess abraded blades (Fig. 51F,G), whereas the blades of those newly formed within the collar fascicles are not abraded (Fig. 52A). In the latter, the boss is squarish; a long part of the shaft preceding the boss is serrated, nearly equal to the length of the blade and the blades end in tapering tips; an unserrated notch is absent. Thoracic uncini bear 8–12 teeth in a single row, and the anterior gouged process; abdominal tori lateral (Fig. 51B) anterior abdominal uncini possess 7–9 teeth and an anterior gouged process. Abdominal neurochaetae possess flattened trumpet-shaped tips, one side drawn out into a tapered process, and with long shafts projecting from their

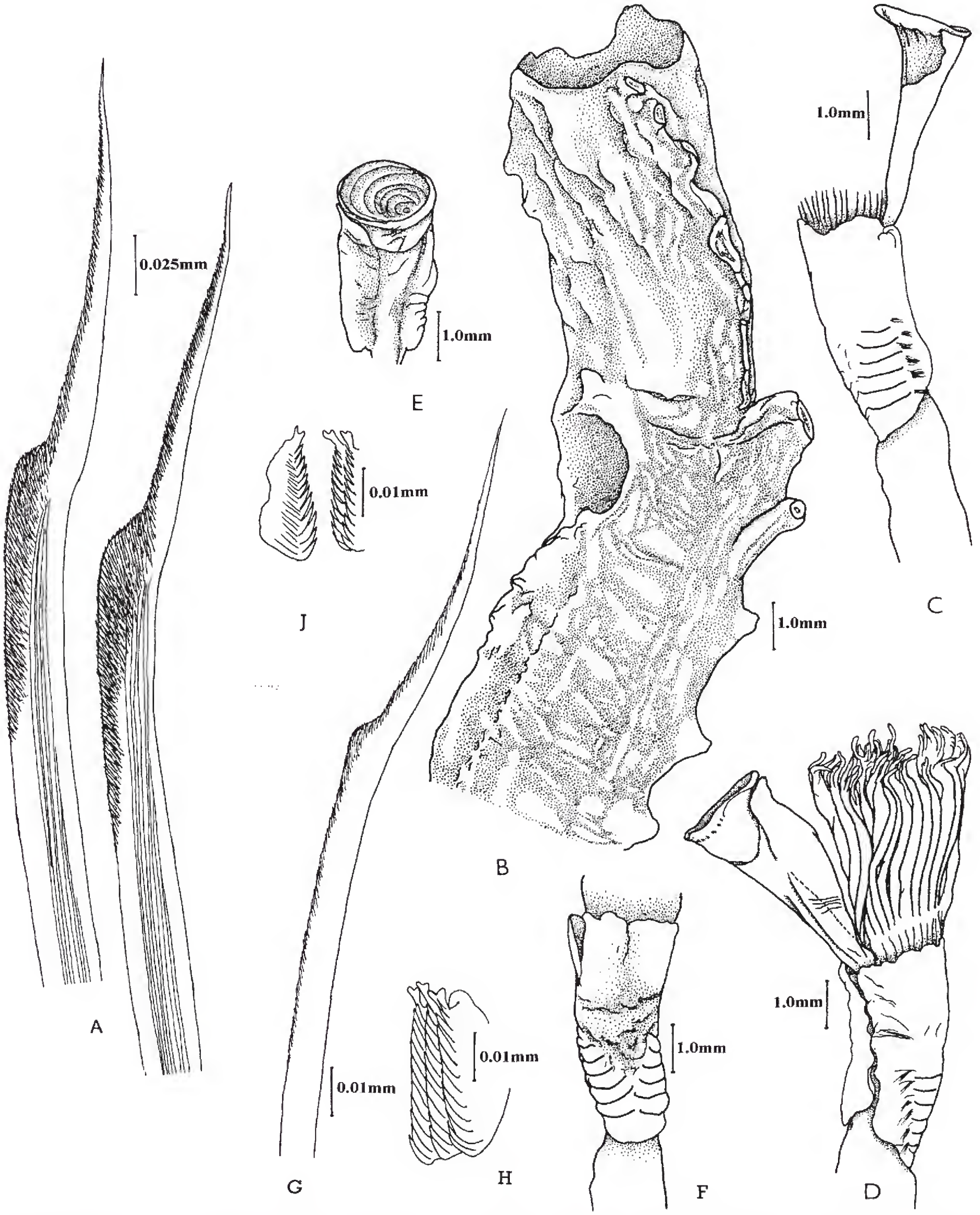

Figure 52. (*A*), *Spirobranchus* sp. 4: bayonet-shaped special collar chaetae from within collar fascicle. B–I, from type material of *Spirobranchus maldivensis* Pixell, 1913, BMNH 1924.6.14.114: (*B*) tube, showing median longitudinal ridge, which consists of fin-shaped parts, some of them low, others triangular, still others forwardly directed truncated rods; (*C*) thorax and operculum viewed from left side; (*D*) dorsolateral view of anterior end of worm and operculum; (*E*) anterodorsal view of opercular plate showing its concentric rings and lack of processes; (*F*) ventral view of thorax; (*G*) bayonet-shaped collar chaeta; note long serrated area of shaft preceding the boss, and that length of the blade is approximately equal to that of serrated area of shaft plus boss; (*H*) thoracic uncini; (*I*) anterior abdominal uncini.

abdomen are present from the 2nd or 3rd anterior abdominal segment onwards (Fig. 51B).

Remarks. *Spirobranchus* sp. 4 superficially similar to *S. tetraceros* with regard to the branched opercular spines borne on a circular opercular plate. However, although the peduncular wings in *S.* sp. 4 and *S. tetraceros* are fringed, those of the former possess a double row of numerous papillae (Fig. 50A,C,E), while those of the latter possess a single row of papillae (Fig. 46D,L). There also appears to be a difference in the maximum number of branchial radioles attainable, about 23 in *S.* sp. 3, but more, about 28–30 in the Kimberleys *S. tetraceros*, for instance. Further studies are needed *S.* sp. 3, including its tube.

Spirobranchus maldivensis Pixell, 1913

Fig. 52B–I

Spirobranchus maldivensis Pixell, 1913: 81, pl. 8, fig. 7.

Material examined. SYNTYPES: BMNH 1924.6.13.114: 3 specimens occurring alongside and attached to each other, coll. C. Crossland, labelled syntypes, type material of *Spirobranchus maldivensis* Pixell (1913).

Additional material examined. BMNH 1939.9.2.554–556, several specimens on a shell, from the Gulf of Oman.

Description

Measurements. From one of Pixell's types, as follows: total length 19.5 mm; length of operculum and peduncle 6.0 mm; long diameter of operculum 2.0 mm. Operculum plus 27 radioles on left side, no rudimentary operculum on right; 28 radioles on right side. Length of abdomen: 11.0 mm; number of segments 52.

Tube. In type specimens, caramel to faintly pinkish in colour, with slightly darker pink along median longitudinal ridge; latter prominent, with conspicuous forwardly directed projections which may be triangular towards the middle of tube, or end in laterally flattened tips with their stumpy ends appearing as if they were broken off. They are low anteriorly, and the median longitudinal ridge itself may be somewhat sinuous. All three types present on one of the tubes (Fig. 52B). Tube colour of specimens in additional material examined, BMNH 1939.9.2.554–556, range from light caramel to brownish and pink. Some have a pair of light brown longitudinal bands along each flank and a pinkish colour along the median longitudinal ridge. Otherwise, the form of the tubes and other characters agree with those of the type specimens.

Worm. Operculum in type material on left side; no rudimentary operculum on right; opercular plate circular, flat, lacks processes but shows concentric circular markings (Fig. 52E); peduncular wings broad and unfringed; 27 radioles on the left, 28 on the right in one specimen, arranged in a circle on each side; inter-radiolar membranes unfringed. One or two whitish patches present at the base of each radiole; uncertain whether they represent eyespots or mere pigment patches in the preserved material. Thorax: slender, its uncinal tori not borne on conspicuous pads (Fig. 52C,D,F).

Chaetae. Bayonet collar chaetae (Fig. 52G) differ from those of other species of *Spirobranchus* hitherto described in this account in being slender, their serrations comparatively inconspicuous along the blade, the boss and the serrated part of the shaft preceding the boss. Thoracic uncini: saw-shaped (Fig. 52H), with about 12–13 teeth, in addition to the anterior gouge; anterior and posterior abdominal uncini similar, the former (Figs 52J) with about 10–11 teeth, and the latter about 10–12.

Remarks. *Spirobranchus maldivensis* can be recognized from most other species of *Spirobranchus* by its simple circular opercular disc, which is devoid of processes, the arrangement of its radioles in a circle, unfringed peduncular wings and inter-radiolar membranes, the form of its bayonet collar chaetae, and the caramel to pinkish colour of its tube. The concentric circular markings on the opercular plate are clearly not scars left by opercular horns that had become detached; horns of *Spirobranchus* species are not deciduous and, if broken off, leave the basal remnants of their horns or a conspicuous "wound" marking the place from which the horns were broken off.

Spirobranchus murrayi n.sp.

Fig. 53A–G

Material examined. SYNTYPES: 2 specimens without their tubes, South Arabian coast, Gulf of Oman, BMNH 1937.9.2.550–553, depth 106 m, otter trawl, Murray Expedition Stn. 71, date 26 Nov.33, labelled specimen Nos. 1 & 2 by present author. 1 specimen, South Arabian coast, Gulf of Oman, same registration number and jar, BMNH 1937.9.2.550–553, depth 13.5 m, triangular dredge, Murray Expedition Stn.53, 2.11.33, labelled specimen no. 3 by present author. They had been identified as *Spirobranchus maldivensis* Pixell according to a label inside the jar; and as *Spirobranchus latiscapus* according to the label on it.

Description

Measurements. in the above three specimens as follows. Total lengths 7.1–11.5 mm; thoracic widths, 1.5–1.6 mm; lengths of operculum and peduncle, 3.0–4.8 mm; lengths of operculum alone, 0.3–0.5 mm; and diameters of opercula, 1.0–1.6 mm. Abdominal lengths 2.6–4.7 mm. Ratios of lengths of operculum and peduncle to the lengths of abdomen in the three specimens: 0.94: 1.0, 1.02: 1.0 and 1.15: 1.0. Numbers of radioles: 20 on each side; 21 on each side and 27 on the left and 29 on the right. Number abdominal segments 40–53.

Tube. Missing in all three specimens.

Worm. Operculum on left, no rudimentary operculum on right. Operculum plus peduncle: about as long as abdomen in preserved material (Fig. 53B). Number of stacked opercular plates observed, including basal plate: 3 (Fig. 53B–D) and 2 (Fig. 53A). Peduncle and wings in all three specimens transparent; wings unfringed (Fig. 53A–D). Largest specimen has 27 radioles plus the operculum on left side and 29 radioles on right. Inter-radiolar membranes: about ¼ as long as radioles; unfringed (Fig. 53E). Number of thoracic chaetigers: 7; apron present. Maximum number of abdominal segments counted: 53.

Chaetae. Special collar chaetae bayonet shaped, with a prominent boss (Fig. 53F,G), sometimes with a constricted notch between boss and blade (Fig. 53G). As also seen in the latter figure, length of the blade is about 1½ times that of serrated distal part of the shaft plus boss. Thoracic uncini bear 13 or 14 teeth, anterior abdominal uncini 10 or 11, in addition to the anterior gouged process.

Remarks. Opercular plates of all three specimens had an epizoic hydrozoan coelenterate belonging to the genus *Teissiera*, Family Teissieridae on them (Fig. 53A), even completely covering the gaps between the opercular plates. A merely cursory examination could possibly result in the present material being identified as belonging to a species of *Spirobranchus* possessing a simple opercular plate, such as *S. maldivensis*, as indeed is evident from the original

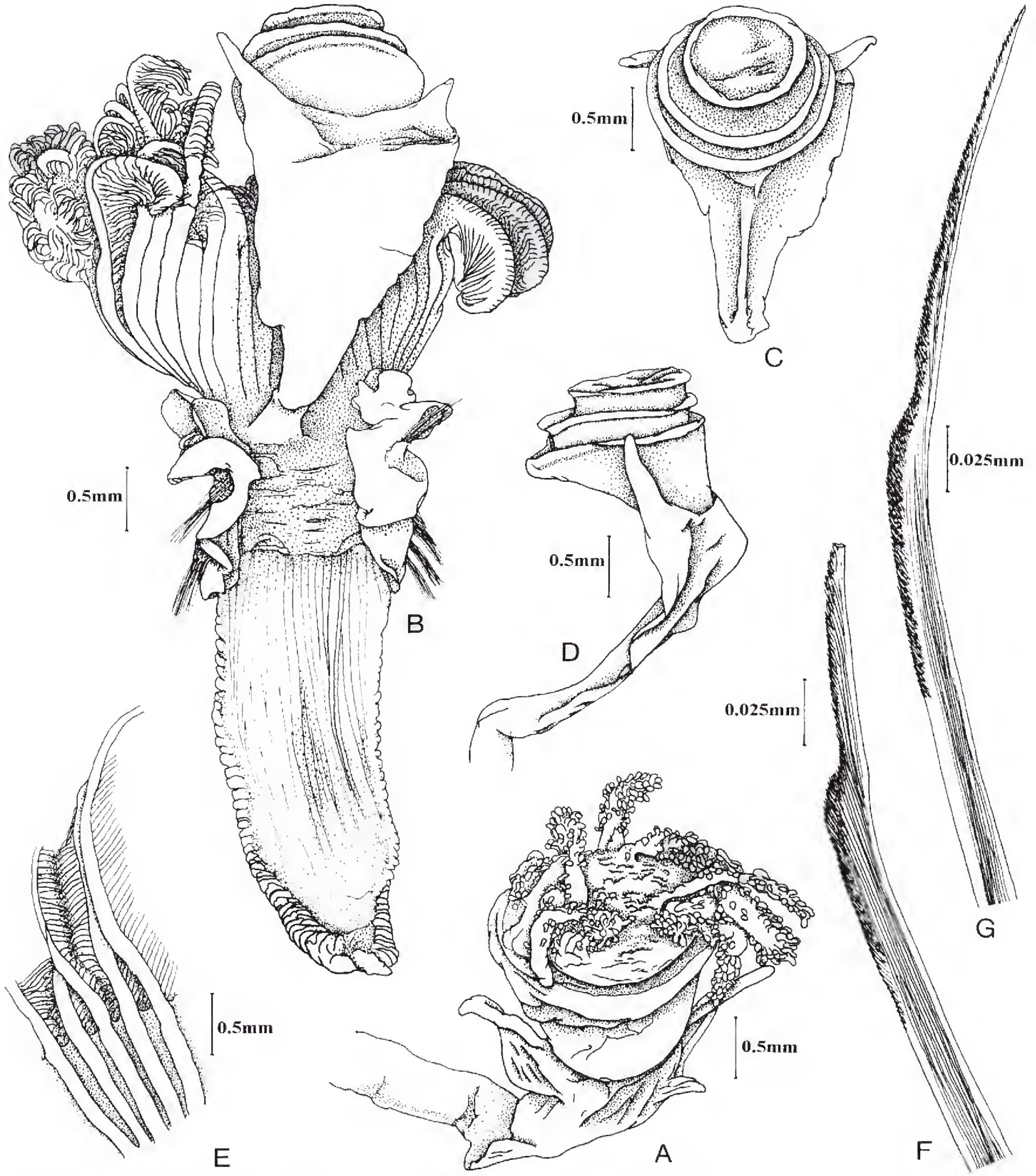

Figure 53. A–G, *Spirobranchus murrayi* n.sp., from Gulf of Oman, South Arabian coast, Murray Expedition stations 53 & 71, BMNH 1937.9.2.550. (*A*) operculum of a specimen, with the Hydrazoan Coelenterate *Teissiera* on its opercular plate; (*B*) dorsal view of a whole worm; its operculum and peduncle is conspicuously long compared to the rest of the body, and its peduncular wings are unfringed; (*C,D*) two different views of the 3-tiered operculum of specimen figured in A, also showing the unfringed peduncular wings; (*E*) some branchial radioles showing the unfringed inter-radiolar membranes; (*F,G*) bayonet-shaped special collar chaetae showing a squarish boss, an indentation between the boss and the blade, and a corresponding outward bend on the opposite side of the blade, the constancy or otherwise of which needs further investigation. The blade is longer than the serrated distal part of the chaetal shaft plus the boss.

identification label on the jar. Removal of the epizoic coelenterate, however, reveals that it is not so. One of the three specimens had subsequently been cleared of the coelenterate which, according to the second label, led to the specimens being identified as *Spirobranchus latiscapus*. Clearing the remaining two worms during the present study revealed that they too belong to the same *S. latiscapus*-like species.

Spirobranchus murrayi n.sp., differs from other "*S. latiscapus*-like" species having stacked opercular plates described in this paper with regard to the following characters. Firstly, with regard to their special collar chaetae: in *S. murrayi* they are bayonet-shaped, a boss is present, and the blade is longer than the serrated distal part of the shaft plus boss (Fig. 53G). In *S. zibrowii* they are not bayonet-shaped, a boss is not distinguishable from the blade, and the distal part of chaetal shaft is not serrated (Fig. 63K). In *S. zelandicus* they are more or less bayonet-shaped, the boss is elongated and merges gradually with the blade, and the blade is about as long as the serrated distal part of the shaft plus boss (Fig. 61F); those of *S. tenhovi* (Fig. 61) are smaller and more slender than those of *S. murrayi*. As in the latter, the blade is longer than the serrated distal part of the shaft in *S.*

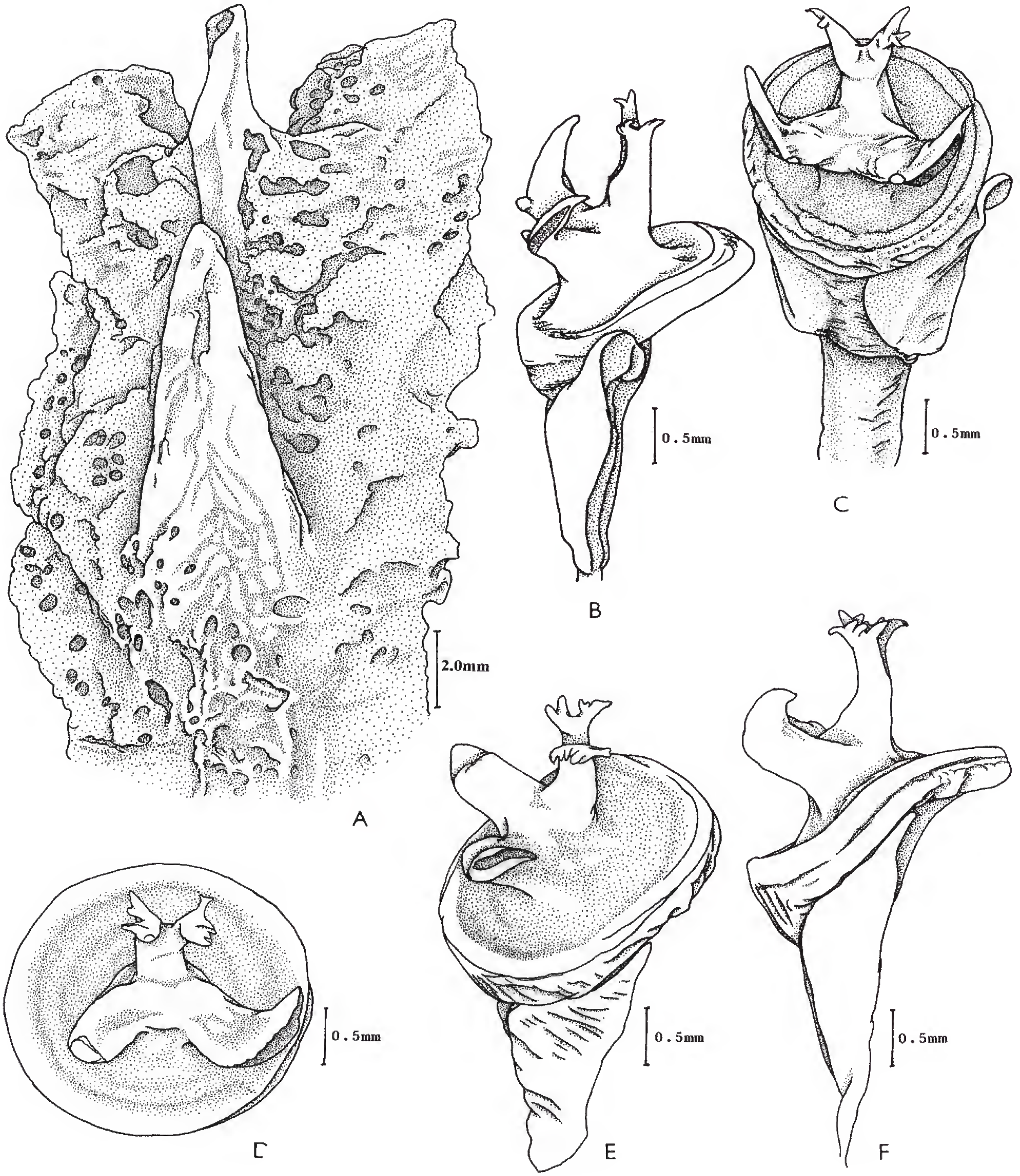

Figure 54. A–F, *Spirobranchus paumotanus* (Chamberlin, 1919) from specimens in sample no. BMNH 1970.855, Royal Society Expedition in 1965 to the Solomon Islands; locality Komimbo Bay, collected and presented to the BMNH by P.E. Gibbs. (*A*) a tube with two massive teeth developed anteriorly, also showing the irregular pits caused by a boring sponge; (*B,C*) operculum of an adult specimen; B, Right lateral view, and C, anterodorsal view. D–F, three different views of the operculum of an adult specimen in which the left dorsolateral opercular process had been damaged: (*D*) anterodorsal view; (*E*) right lateral view, and (*F*) right lateral view.

tenhovi, but unlike in the former, the boss gradually merges with the blade and is barely recognizable.

Total length of operculum and peduncle is approximately equal to that of its abdomen in *S. murrayi* (Fig. 53B). On the other hand, the abdomen is significantly longer in other *S. latiscapus*-like species: in *S. zelandicus* and *S. tenhovi*: about twice as long as the operculum plus peduncle. Furthermore, in *S. murrayi*, the ratio of the diameter of the basal opercular plate to length of opercular peduncle (based on those described in Fig. 53B,D), is approximately 1:2. In *S. zibrowii* (based those in Fig. 63J,G,H) approximately 1:1. In *S. zelandicus* (based on those in Fig. 62B,D,E) it is 1:1.3. In *S. tenhovi*, new species, (based on those in Fig. 63C–E) is 1:2.7–3.6.

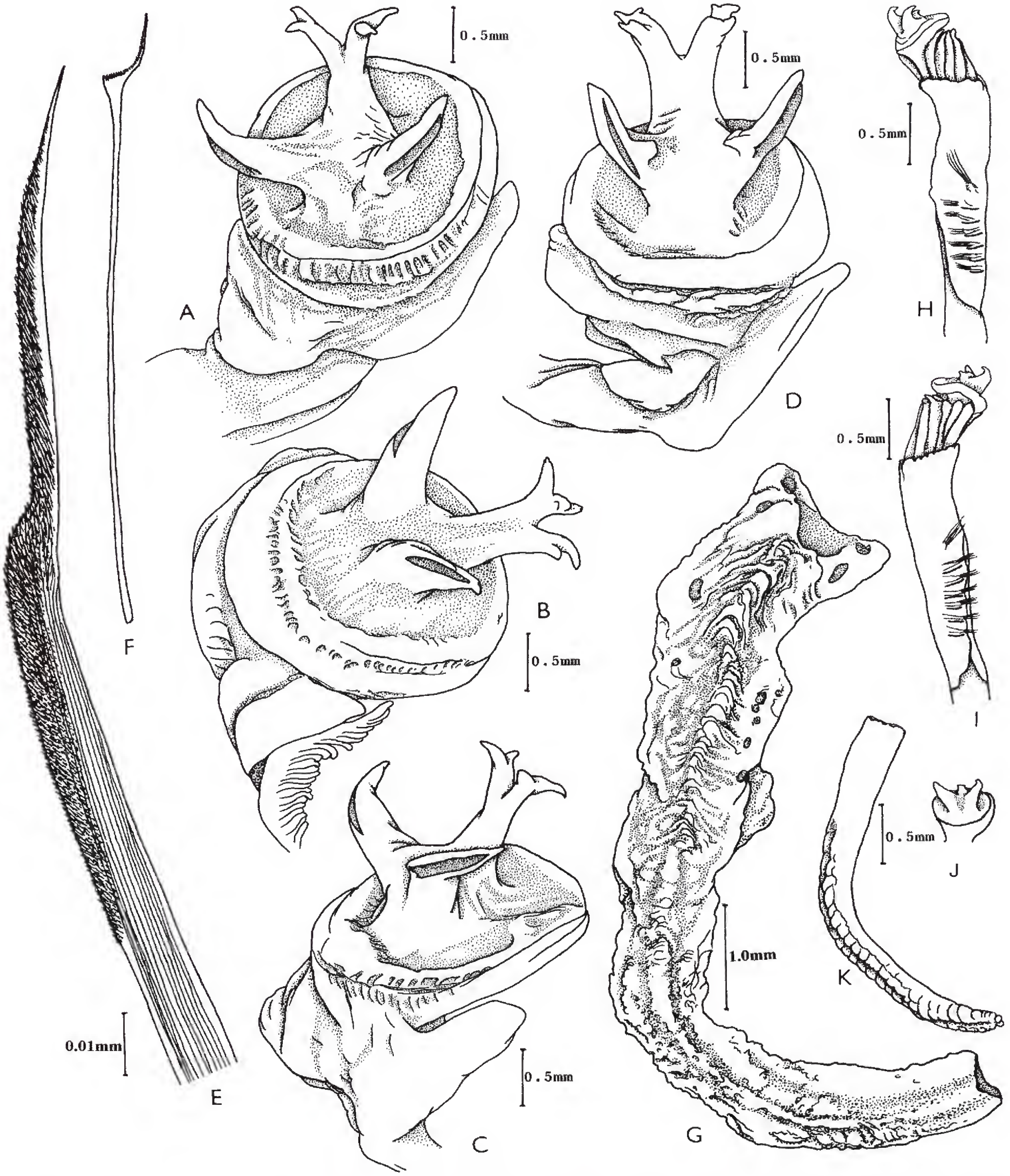

Figure 55. A–K, *Spirobranchus paumotanus* (continued from BMNH 1970.855). A–D, operculum of an adult specimen: (*A–C*), three right dorsolateral views; (*D*), dorsoanterior view; (*E*) a bayonet-shaped special collar chaeta; (*F*) long-shafted abdominal chaeta. G–K, juvenile specimen: (*G*) tube; (*H*) right lateral view of anterior end of worm; (*I*) left lateral view of anterior end; (*J*) right dorsolateral view of operculum; (*K*) abdomen.

Based on a comparison of the number of radioles in relation to total length of worm, *S. murrayi* is apparently also a smaller species. The largest of the three specimens is only 11.5 mm long, and its abdomen is 4.7 mm, comparatively broad (Fig. 53A), and has only 53 segments, but possesses 27 radioles on the left side and 29 on the right; number of its radioles exceeds that, for example, a specimen of *S. zibrowii*, which is over twice its total length (26.8 mm), has an abdomen with 88 segments, but only 21 radioles on the left and 22 on the right. In the new species *S. tenhovi*, to be described later, a worm with a total length of 34.5 mm and having about 75 abdominal segments has 33 radioles on the left and 33 on the right.

Etymology. Named after the Murray Expedition during which the specimens were collected.

Spirobranchus paumotanus (Chamberlin, 1919)

Figs 54A–F, 55A–K

Pomatoceros paumotanus Chamberlin, 1919: 479, pl. 78, figs 6–9.
Spirobranchus paumotanus (Chamberlin) 1919.—Nishi & Asakura (1996: 51–54).
Spirobranchus giganteus.—Gibbs (1971: 203, in part).

Material examined. BMNH 1970.855, numerous specimens, including a tiny juvenile, 5; Solomon Islands, separated in Royal Society Expedition to the Solomon Islands, coll. and presented by P. Gibbs. Identified as *S. giganteus* (Pallas, 1766), according to label on the jar.

Description

Measurements. Maximum width of tube figured (Fig. 54A), including its lateral flanges: 10.0 mm; in comparison with latter, length of second spine also 10.0 mm and width at its base, 5.0 mm; diameter of tube aperture itself is only 2.5 mm, approximately equal to diameter of opercular plate. Total lengths of two of the largest specimens, 35.0 mm & 31.5 mm; thoracic widths, 2.2 mm and 2.5 mm; lengths of operculum and peduncle 5.0 mm & 4.0 mm, heights of longest opercular horn (mid-ventral one) 1.5 mm and 1.0 mm; diameters of opercular plate 2.2 mm and 2.3 mm; numbers of radioles: numerous; spirally arranged. Number of spirals on each side: 4 and 4, and 4 and 4. In a third, somewhat contracted specimen, there are 5 spirals on each side. Lengths of abdomen: 24.0 mm and 22.0 mm; numbers of abdominal segments: 88 and 91.

Tube. White; mutually bonded and aggregated into clumps, their shape quite characteristic, when unhindered in their formation by competing individuals in the same clump. Each tube has an obtusely triangular cross-sectional appearance, and initially only a low median longitudinal ridge (Fig. 54A), then abruptly develops 1 to about 4 or 5 massive forwardly directed teeth (the one figured has two); most anterior tooth projects conspicuously over the aperture. A very wide lateral flange present on each side. Tooth-like processes at the anterior ends of tubes may be hindered from developing or may be obliterated by tubes of competing individuals growing over them. Apparently, once a competing individual grows over the aperture of another tube, the latter continues to grow underneath the former without developing any more such processes. Consequently, the tube growing underneath may only bear 1 to a few such processes posterior to where the competing tube grows over it. Shapes of such processes and the direction in which they point are also variable. The most anterior process, for instance, may be pointed, somewhat flattened, or shaped like a cobra's hood, and directed forward or laterally. Tube surface frequently pitted with irregularly shaped foramina (Figs 54A, 55G), evidently caused by a boring sponge; some tubes lack them.

Worm. The following description is based on examination of 8 adult specimens. Operculum on the left, no rudimentary operculum on right; opercula of 4 above specimens damaged; hence description based remaining 3, while a partly damaged operculum is also described from another. Opercular plate in all specimens circular, somewhat concave, and bears three horns which arise from a short stout stem (Figs 54B–F, 55A–D). Two of the horns are dorsolateral, the third ventral. As seen in the figures, the dorsolateral horns are quite horn-like and curved outwards and ventrally. Each dorsolateral horn characteristically bears along its lateral edge, what is apparently a groove, but is actually covered by a brownish chitinous layer; it may sometimes also bear a small knob dorsomedially at its base, (Fig. 54B–D). The ventral horn is also characteristic. Viewed laterally, it is the tallest of the three, projecting conspicuously anteroventrally, then curved anteriorly, and ending distally in two main outwardly curved branches(Figs 54B,F, 55B). Each of the latter may, in turn, be dichotomously branched once or twice towards its tip to give rise to short processes, which are outwardly curved (Figs 54B–F, 55A–D). An operculum with the tip of the left dorsolateral horn damaged is shown in Fig. 54D,E.

Peduncular wings: unfringed (Figs 54B,C,E,F, 55A–D). Radioles numerous, arranged spirally on each side; number of whorls in each spiral mostly 4 on either side; 5 on either side in one specimen. Prostomial ocelli are not discernible. On the ventral side of the thorax, distances between corresponding pairs of uncinal tori decrease posteriorly leaving an inverted triangular area between them; the last pair of tori meeting mid-ventrally in worms fixed within their tubes; not seen in juvenile (Fig. 55H,I). An apron is present. Maximum number of abdominal segments counted, 91. Anal segment bears a pair of small rounded swellings in juvenile (Fig. 55K), lacking in adults.

Chaetae. Special collar chaetae bayonet-shaped, boss not squarish in side view, curved smoothly from shaft to the base of the blade (Fig. 55E); blade is considerably narrower than shaft; approximately equal in length to that of serrated distal end of chaetal shaft. Remaining collar chaetae: similar to special collar chaetae, but considerably narrower. Thoracic uncini: saw-shaped with 12–14 teeth in a row; anterior abdominal uncini similar, with about 12 teeth in a row; both in addition to the anterior gouge. Abdominal neurochaetae with long shafts projecting from the body wall are present from the third segment onwards. Indeed, they are quite long in the anterior segments, the length of the shaft alone being about 15 times as long as that of the distal trumpet-shaped part and its attenuated process (Fig. 55F).

Juvenile specimen. With a width of only 1.5 mm at its anterior end, the juvenile tube is similar to the posterior part of adult tube. It is obtusely triangular in cross-section, has only a smooth median longitudinal ridge, and anteriorly directed transverse furrows, those at the anterior end foreshadowing the tooth-like processes that have yet to be developed (Fig. 55G). A wide flange present along each side. Irregular foramina formed by a boring sponge present even at this young stage. Total length of worm 7.0 mm; operculum on left side, its two dorsolateral horns have the typical shape, but the ventral horn, which has yet to be developed, is represented only by a small knob (Fig. 55H–J). Opercular peduncle unfringed (Fig. 55H); radioles number 5 on each side, arranged in a circle, which is evidently the plesiomorphous condition. Length of thorax 3.5 mm; apron present; length of abdomen 3.5 mm, about half achaetous anteriorly, the remaining half with about 23 chaetigers; anal segment bears a pair of small rounded knobs (Fig. 55K), which are lacking in adults.

Remarks. The above material of *S. paumotanus* (Chamberlin, 1919) from the Solomon Islands were identified by Gibbs (1971: 203–204) as *S. giganteus* (Pallas, 1766). Apparently, Gibbs's paper was published before Hove's paper mentioned below became available.

Ten Hove (1970: 14) suggested that two subspecies could be distinguished under the genus *Spirobranchus*, namely, *S. giganteus giganteus* (Pallas, 1766) from the western Atlantic and *S. giganteus corniculatus* (Grube, 1862), new combination, from the Indo-West Pacific. Following further investigations, ten Hove (1994: 112–113) referred the *S. giganteus corniculatus*-complex to the *S. corniculatus*-complex, noting that the opercular plate is egg-shaped in the latter. As seen from the description of *S. corniculatus* (Grube, 1862) earlier in this account (Figs 38A–D, 39A–D,I,J), the opercular plate is indeed conspicuously wider anteriorly than posteriorly, and its outline is more or less like a longitudinal section of an egg or a pear.

In contrast, that of *S. paumotanus* is circular (Figs 54B–F, 55A–D,H,J), as it is in species such as *S. tetraceros* (Schmarda, 1861), (*vide* ten Hove, 1970: 6, and Figs 44C and 45G–I), as also in *S. gardineri* Pixell, 1913 (ten Hove: 1994: 113) and other species of *Spirobranchus* described in this paper. There are, however, also other differences between *S. paumotanus* and *S. corniculatus* with regard to the operculum. Each dorsolateral horn in the former is unbranched, anteroventrally curved, pointed, and has a characteristic posterolateral groove covered by a brownish chitinous layer (Figs 54B–E, 55A–D). In contrast, each dorsolateral horn in *S. corniculatus* usually ends in a pair of short pointed process, while also bearing a group of short processes dorsally and a short dorsal curved spine beyond the latter and lack the characteristic groove covered by a brownish chitinous layer (Figs 39D,I–J; 40A–C). The ventral horn in *S. paumotanus* is also characteristic, being the highest of the three and projects conspicuously, anteroventrally, and then curves anterodorsally. It ends in two main outwardly curved branches, which may, in turn, be dichotomously branched at its tip once or twice to give rise to short outwardly curved processes (Fig. 54B–F). In contrast, a ventromedian process is frequently absent in *S. corniculatus* (Figs 39A,B,D,I,J; 40C), sometimes being represented by a knob (Fig. 39C) or by an aberrant process (Fig. 40A,B).

There are also differences with regard to tube colour and form, maximum sizes attained, maximum numbers of radiolar whorls, and number of teeth in the thoracic uncini. The tube of *S. paumotanus* is white and initially bears only a low median longitudinal ridge, which abruptly develops one to few massive forwardly directed teeth, with the most anterior one often projecting conspicuously over the aperture. On the other hand, that of *S. corniculatus* ranges in colour from yellowish orange to bright orange and has a single, somewhat smooth, median longitudinal ridge, with fine transverse ridges on either side of it. It does not bear similar massive teeth, with one of them projecting over the aperture of its tube. The maximum total length attained by the worm in *S. paumotanus* is about 35.0 mm, with a thoracic width of 2.5 mm, as opposed to over 110.0 mm and 10.0 mm, respectively, in *S. corniculatus*. A specimen of *S. corniculatus* from Malé described later in this paper has a total length of 90.3 mm and 226 abdominal segments. On the other hand, the maximum number of abdominal segments in *S. paumotanus* is probably less than 100. The maximum number of radiolar spirals observed in *S. paumotanus* is 5 on each side. In comparison, four out of the five specimens of *S. corniculatus* from Kimberleys collection AM W202960, possess 7 spirals on each side, and the fifth 5. Again, 10 radiolar spirals were counted in the very large specimen from Kimberleys collection AM W202958. There is also a significant difference with regard to the maximum number of teeth in the thoracic uncini. It is 12–14 in addition to the gouged process in *S. paumotanus*, whereas it is double that, 22–24, in *S. corniculatus*.

Mörch (1863: 411, fig. 26) describes *Pomatoceros bucephalus* from Zamboanga, the Philippines, which is very similar to *S. corniculatus* (Grube, 1862). It is synonymized with the latter here, which has priority over the former.

Gibbs (1969: 203) describes the habitat of *S. giganteus* as "embedded in Porites boulders (Gibbs, 1969: fig. 138) and encrusting on reef platform."

However, information concerning the habitat of the Komimbo Bay sample, BMNH 1970.855 (= *S. paumotanus* [Chamberlin, 1919] in the present account) is quite different and indeed quite interesting, since it is unusual for a *Spirobranchus* species. According to the label in the jar containing the above specimens collected on 19/08/65, the species lives "Under boulders in muddy silt." The label also states "MTL–LWM, silt."

Spirobranchus pseudopolytremus n.sp.

Fig. 56A–I

Pomatoceros polytrema (Philippi, 1844).—Dew (1959: 42, fig. 15,16).

Material examined. HOLOTYPE and PARATYPE, BMNH 1959.10.10.39; 2 specimens with only anterior parts of their tubes, one worm complete, the other incomplete posteriorly, Cronulla, New South Wales, 34°04'S 151°09'E, identified by D. Straughan as Temporaria polytrema (Philippi, 1844), and presented by B. Dew. Worms in this collection not too well preserved, apparently having been dried up previously and re-introduced into alcohol.

Description

Measurements. Maximum external diameter of tube 5.2 mm, including the lateral flanges; 3.6 mm, excluding flanges. Maximum height, including MLR, 5.0 mm. Total length of complete worm (holotype), 10.0 mm; width of thorax 1.5 mm; length of operculum and peduncle 3.0 mm; diameter of opercular cap 1.7 mm; and length of abdomen 4.3 mm. Branchial crown with 15 radioles plus operculum on left and 14 radioles on the right. In the second specimen (paratype) branchial crown has 18 radioles on each side, in addition to the operculum on the left.

Tube. Wide anteriorly with a broad flange, abruptly narrows posteriorly (Fig. 56A,B); MLR low smooth, somewhat irregularly formed, ends anteriorly as a small low tooth over aperture. A row of irregularly formed foramina present on each side of MLR, at its base (Fig. 56B). An irregularly formed, low, narrow, LLR present on either side of the MLR. A row of irregularly formed foramina present on each side at the base of each LLR. Faint, smooth, anterolaterally directed ridges and grooves, and foramina, extend into sides of tube and lateral flanges (Fig. 56A,B).

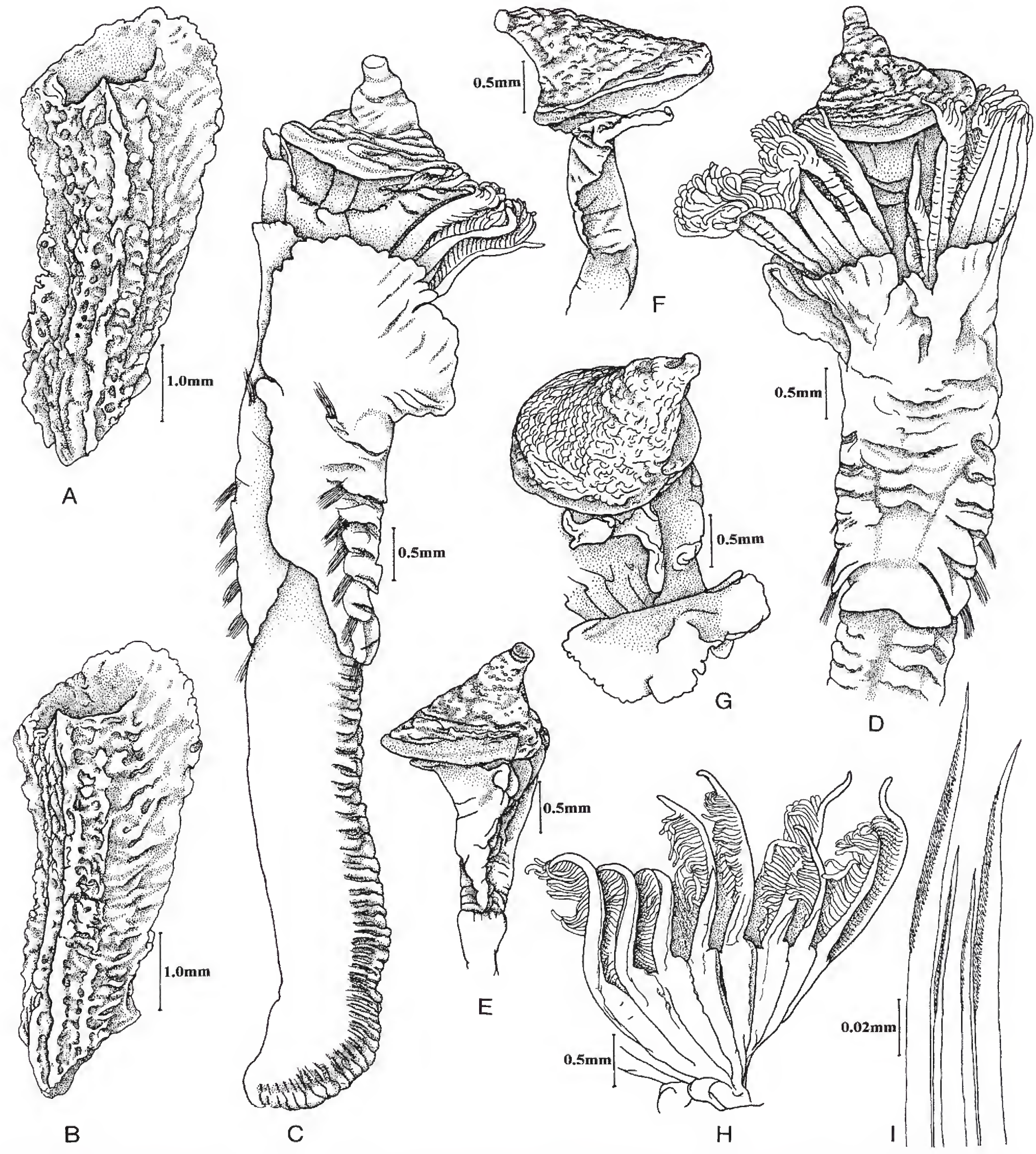

Figure 56. A–I, *Spirobranchus pseudopolytremus* n.sp., from Cronulla, NSW Australia: BMNH 1959.10.19.39 (2 specimens) collected and presented by Barbara Dew. (*A,B*) two views of tube; (*C*) dorsal view of holotype; (*D*) ventral view of anterior end of latter; (*E*) left lateral view of operculum of latter; (*F,G*) two views of operculum of paratype; (*H*) branchial radioles showing the pinnule-free tips and unfringed inter-radiolar membranes; (*I*) two special collar chaetae with two slender capillaries accompanying them.

Worm. Operculum on left side, no rudimentary operculum on right. Number of radioles: 15 on the left and 14 on right in holotype; 18 on each side in paratype. Operculum conical, its peak dorsally curved (Fig. 56C–G); although the peak is dorsally directed in holotype, it is a short cylindrical stump in paratype (Fig. 56C–E). A fine granular overlay can be seen at higher magnifications under certain angles of illumination (Fig. 56G). Opercular peduncle fringed (Fig. 56G). Dorsolateral and ventral views of the holotype presented in Fig. 56C,D. Radioles arranged in a circle; their pinnule-free tips thicker than and somewhat longer than preceding pinnules. Inter-radiolar membranes present; unfringed (Fig. 56H). Collar conspicuously broad (Fig. 56C,D); thorax consists of 7 chaetigers; prostomial ocelli and thoracic glands not discernible; apron, present (Fig. 56D). Abdomen of holotype has about 45 segments. Abdominal tori, short and lateral (Fig. 56D).

Chaetae. Special collar chaetae stout and truncated, like acicula, serrated (Fig. 56I); no indication of a boss or serrated part of shaft preceding it; at the commencement of serrated blade-like part, width of clear unserrated part of shaft is 2½ to 3 times that of serrated part of blade (Fig. 56I). Chaetae accompanying special collar chaetae highly reduced, in comparison. Uncini saw-shaped; thoracic uncini with about 9 or 10 teeth, and posterior abdominal uncini about 11, arranged in a single row, in addition to the anterior gouged process; sides of latter pointed and directed outwards.

Remarks. According to a note in the jar by ten Hove, "taxonomic change to be processed = *Pomatostegus polytrema*." The latter was transferred to the genus *Spirobranchus* by Bianchi (1981: 107). As discussed in the remarks under *Spirobranchus* sp. 1, cf. *polytremus* (Philippi, 1844) earlier in this paper, it appears that there are a number of *Spirobranchus polytremus*-like species in the Indo-West Pacific area, which need to be sorted out. Imajima (1977: 102–106) remarks that "It is unlikely that" the species described by him "will prove to be the same as the Mediterranean species". He decided not to name his species in view of the complexity of the group involved, the confusion of names by previous authors, and the scarcity of data on infraspecific variation of the individual, and expressed the need for "a full-scale revision of the group." For the same reason, the *S. polytremus*-like material from the Kimberleys was not identified above.

However, as seen from Fig. 40D–F in this account, and, for example, Bianchi (1981: fig. 41c,d) that, although the operculum of the Kimberleys and Mediterranean species are somewhat similar, there are important differences with regard to their tubes. The tube of *S. pseudopolytremus* n.sp., (Fig. 56A,B) is quite different from that of *S. polytrema* from the Mediterranean, e.g., as figured by Bianchi (1981: fig. 41a,b); while that of the former is wide anteriorly, and abruptly narrows posteriorly, it is long and sinuous in the latter.

The tube of *S. pseudopolytremus* is superficially similar those of two other new species are dealt with in the present paper, namely, *S. elatensis* and *S. zibrowii*. However, whilst the MLR in *S. pseudopolytremus* is low and ends in an inconspicuous process over the aperture (Fig. 56A,B), it is high, thick, and ends in a conspicuous projection over the aperture in *S. elatensis* (Fig. 50B) and *S. zibrowii* (Fig. 63A,B,D). The three species also differ amongst themselves with regard to their opercula. In both *S. pseudopolytremus* the operculum is conical, but whereas that of the former lacks any processes at its apex (Fig. 56E–G), that of the latter bears a group of reduced *S. tetraceros*-like processes at its apex (Fig. 50C,D). On the other hand, the operculum of *S. zibrowii* bears 2 to a few super-imposed circular discs (Fig. 63E–J).

Although there are some similarities with regard to special collar chaetae among *Spirobranchus* sp. 3, *S. zibrowii* and *S. pseudopolytremus*, there are also differences. Those of *S.* sp. 3 lack a boss at the end of the chaetal shaft. However, the transition between the end of the shaft and the beginning of the blade can be recognized at the bend along the serrated side of the chaeta (Fig. 49D). As seen in the latter figure, another important character is that the serrated distal part of the chaetal shaft is longer than the blade. The special collar chaetae of *S. zibrowii* (Fig. 63K) differ from those of *S.* sp. 3 in that the distal part of its chaetal shaft is unserrated, and that it lacks a boss. Although the special collar chaetae of *S. zibrowii* and *S. pseudopolytremus* are superficially similar in lacking a serrated distal part of the blade, an elongated boss with a faint indentation between the latter and a reduced blade can be recognized in those of *S. zibrowii* (Fig. 63K) unlike in *S. pseudopolytremus* (Fig. 56I). Moreover, those of *S. zibrowii* (Fig. 63J) are long and slender compared those of *S. pseudopolytremus* (Fig. 56I), which appear to be aciculate.

Etymology. Named *Spirobranchus pseudopolytremus*, (pseudo = false), to distinguish it from the "*S. polytrema* (Philippi, 1844)-like group of species" which need to be sorted out.

Spirobranchus semperi Mörch, 1861

Fig. 57A–H

Spirobranchus semperi Mörch, 1861: 405.
Spirobranchus semperi.—Pillai (1960: 17, fig. 6E–I).
Spirobranchus semperi Mörch, 1861, var. *acroceros*.—Willey (1904: 318, pl. VII, fig. 193), Pillai (1960: 18, fig. 7A–C).
Serpula quadricornis.—Grube (1878: 275, pl. XV, fig. 6).

Material examined. 2 worms and a tube, BMNH 1959.12.16.11/12, Pearl Banks, Sri Lanka, collected and identified as *Spirobranchus semperi* Mörch, 1861 by Pillai (1960?); as *S. tetraceros* (Schmarda, 1861) by ten Hove in 1970, according to a label in the jar. Two worms and a tube, BMNH 1959.12.16.9, Pearl Banks Sri Lanka, collected and identified by Pillai as *Spirobranchus semperi* Mörch, 1861, var. *acroceros* Willey, 1904; as *S. tetraceros* (Schmarda, 1861) by ten Hove in 1970, according to a label in the jar.

Description

Measurements. For above specimens identified as *S. semperi* Mörch, 1861, by Pillai (1960), as follows: tube at aperture, 11.2 mm wide and 5.2 mm high, including the median longitudinal ridge; total length of worm 30.5 mm; abdomen 18.0 mm. In those identified as and *S. semperi* Mörch, var. *acroceros* Willey, by Pillai (1960): height of tube at aperture, 7.0 mm, including median longitudinal ridge; total length of larger worm, 17.5 mm, its abdomen 12.0 mm;

Tube. Colour, in above specimens identified as *S. semperi* Mörch, 1861, bright pink in patches on a white background; in those identified as *S. semperi* Mörch, var. *acroceros* Willey, pinkish orange at aperture, secondarily overlaid with a light bluish-grey colour, apparently by an encrusting organism. As regards tube shape, both, those identified as *S. semperi* Mörch, 1861, and *S. semperi* Mörch, var. *acroceros* Willey, possess only a single, prominent, thick, sinuous median longitudinal ridge, which projects somewhat over the aperture (Fig. 57A,B).

Worm. In both *S. semperi* Mörch, 1861, and *S. semperi* Mörch, 1861, var. *acroceros* Willey, operculum on left side, no rudimentary operculum on right. Opercular plate: circular; bears 4 stiff chitinous horns, two dorsolateral, and two ventral. Each dorsolateral horn bears only a single very short dorsomedial branch; short, curved, stiff chitinous spines occurring along its branches, simple medially, mostly bifid dorsolaterally (Fig. 57C,D). Peduncular wings: fringed. Radioles arranged in a circle, 26 on each side in former, 24 on each side in latter; inter-radiolar membranes present and unfringed in both.

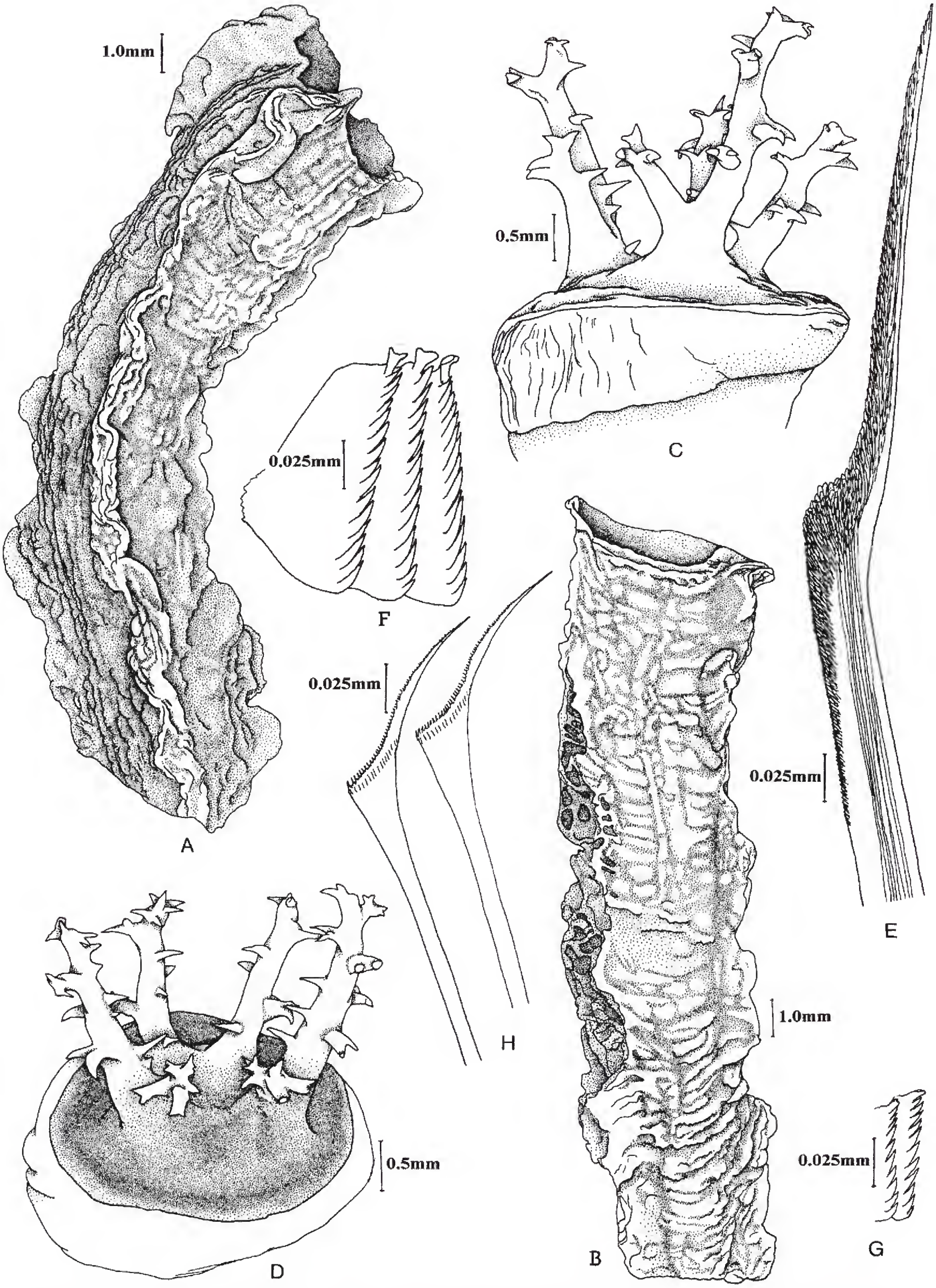

Figure 57. A–H, *Spirobranchus semperi* Mörch, 1861; from the Pearl Banks, Sri Lanka, determined by Pillai (1960). (*A*) tube viewed from above; (*B*) lateral view of tube; (*C*) opercular horns, viewed laterally; (*D*) an anterodorsal view of operculum; (*E*) bayonet-shaped special collar chaeta; (*F*) thoracic uncini; (*G*) anterior abdominal uncini; (*H*) abdominal neurochaetae.

Chaetae. Special collar chaetae of *S. semperi* bayonet-shaped (Fig. 57E): blade narrow and tapering, about half as wide as the distal part of the shaft, about 1½ times the length of serrated distal part of shaft, boss squarish. Thoracic uncini saw-shaped (Fig. 57F) and bear about 15 teeth and an anterior gouged process. Special collar chaetae of *S. semperi* Mörch, 1861, var. *acroceros* are similar (Pillai, 1960: fig. 7B), except that the chaetal shaft on the opposite side of the boss is more curved.

Remarks. *Spirobranchus semperi* can be distinguished from *S. tetraceros* as follows. In *S. semperi*, tube colour is bright pink to pinkish orange on a white background, has a more or less circular outline, and a high, prominent

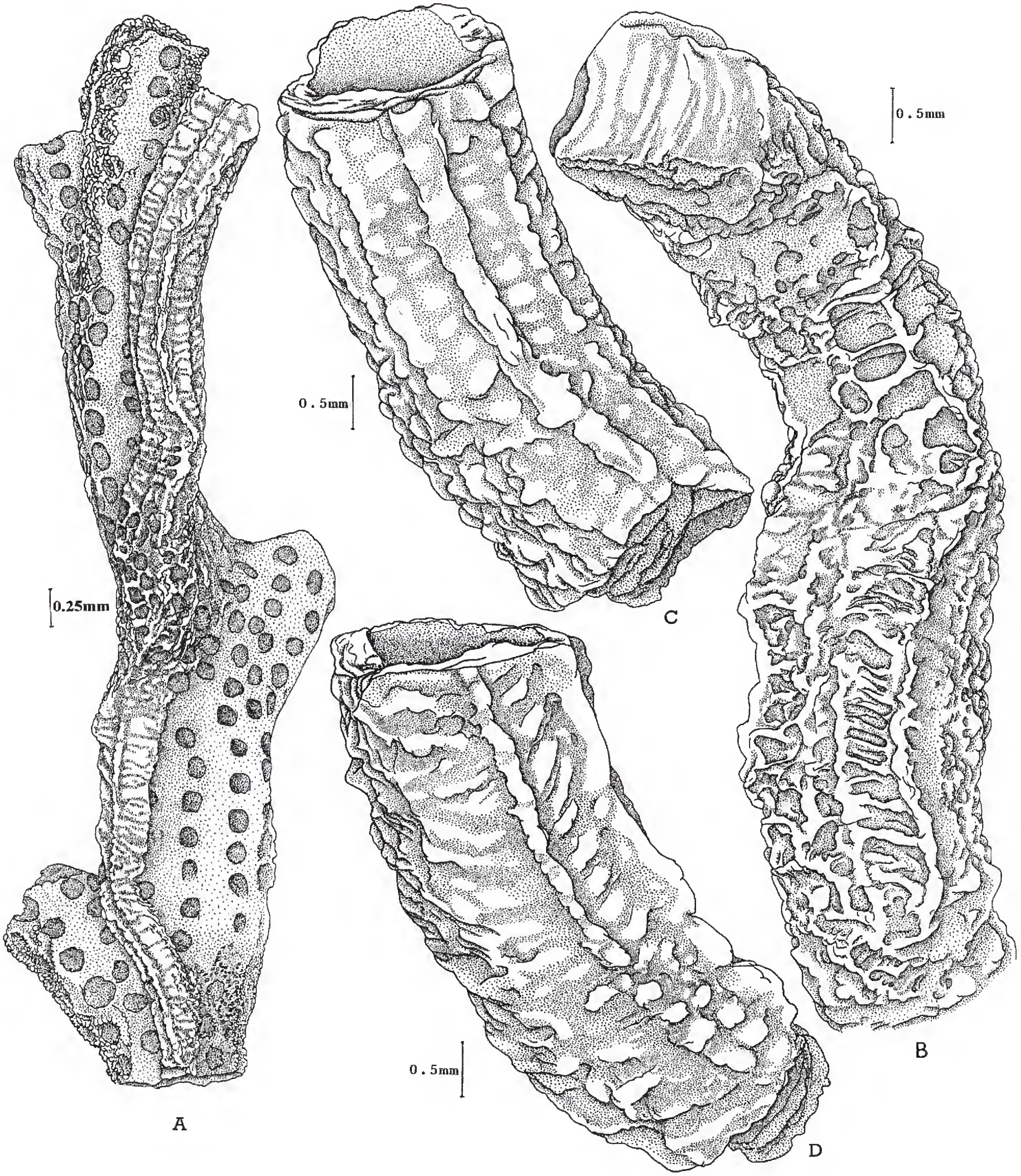

Figure 58. A–D, *Spirobranchus* sp. 5. (*A*) tube on coral; normally overlaid with the coral on which it grows, most of it has been cleared, except towards its middle; (*B*) part of a tube viewed from the side attached to the substratum. More or less transversely elongated chambers are present on either side of the mid-ventral line; (*C,D*) dorsal views of two portions of a tube: a comparatively wide, nearly horizontal area occurs on either side of a smooth MLR, which may be discontinuous in places. Along the lateral border of each horizontal area is a LLR.

thick, wavy MLR which ends anteriorly as a short pointed tooth over the aperture (Fig. 57, A,B). Operculum in the larger specimen bears four separate horns, the dorsal pair being longer than the ventral pair. Each of the dorsal pair of horns is branched only once, one branch being dorsomedial and the other dorsolateral (Fig. 57C,D), the former being very short compared to the other. The two ventral horns are un-branched. Inter-radiolar membranes are unfringed. The second specimen is similar, although its two ventral opercular horns appear to arise from a common base. In the two specimens identified above as *S. semperi* var. *acroceros* are similar, but for the fact that its four horns, which comparatively shorter, arise from a conical opercular plate. Its inter-radiolar membranes are also unfringed, and

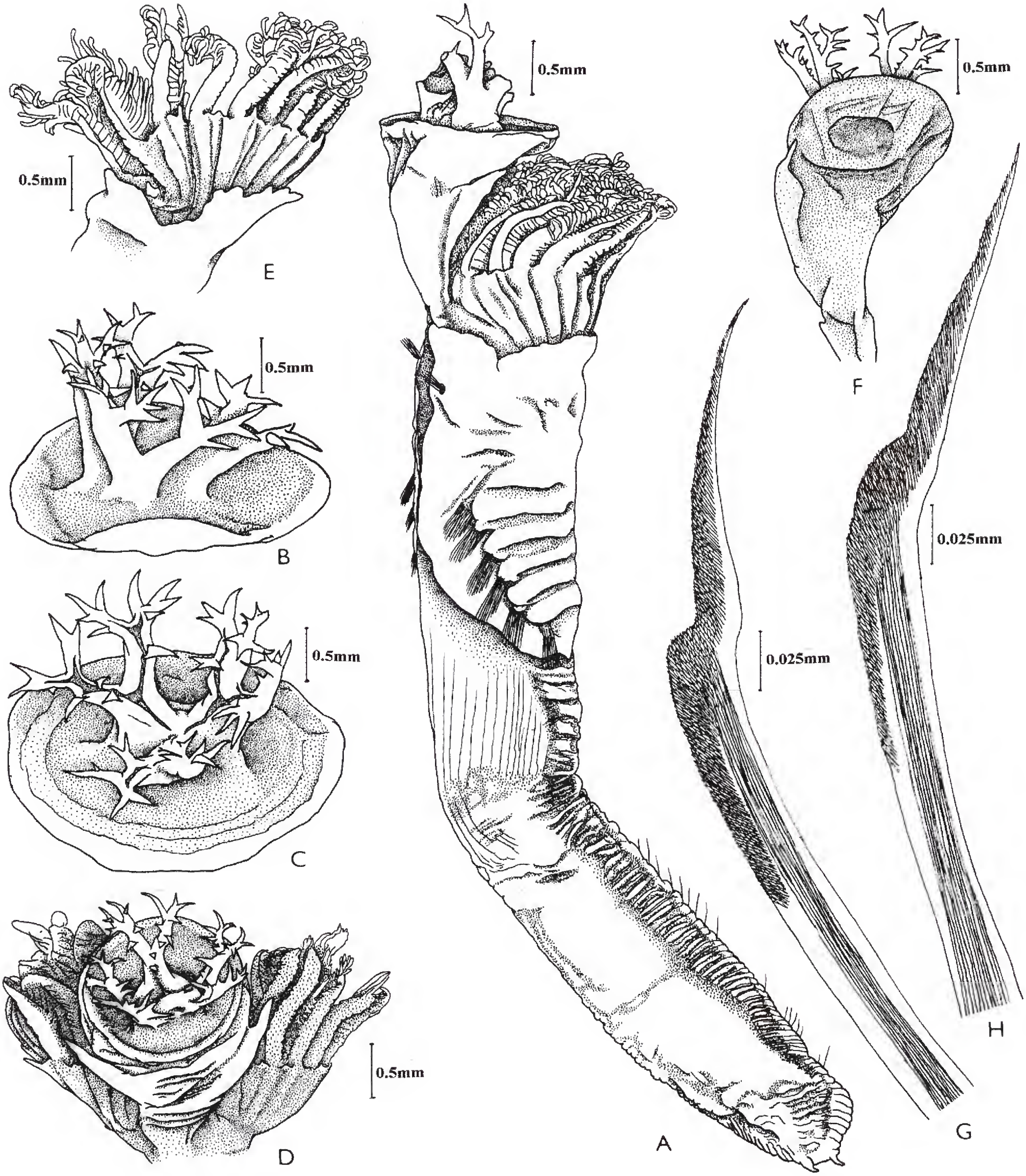

Figure 59. A–H, *Spirobranchus* sp. 5. (*A*) an entire worm; opercular horns are damaged but rest of the body is intact; shows unfringed peduncular wings, inter-radiolar membranes unfringed or bearing a single papilla; abdominal neurochaetae with long shafts projecting beyond body wall and anal segment bearing a pair of papillae; (*B*) lateral view of the opercular plate and horns of another specimen; dichotomies apparently similar to that of *S. kuwaitensis*, as also is the spine preceding the second dichotomy, which is directed towards the centre of the opercular plate; (*C*) operculum and spines viewed from anterior end: opercular spines, dichotomies, and form and sizes of the lateral spines are quite different from those of *Spirobranchus semperi* Mörch, 1861, (Fig. 56C,D); shows the fissures along the main branches of the opercular spines; (*D*) operculum and spines, and radioles, viewed from the anterior end; shows fissures along the main branches, and the medial spines. The inter-radiolar membranes possess only a single insignificant papilla; (*E*) branchial radioles: showing inter-radiolar membranes bearing single papillae; (*F*) operculum of a juvenile worm viewed from below, showing the presence of a central hollow in the opercular plate, and the unfringed peduncular wing. G,H, bayonet-shaped special collar chaetae: (*G*) an abraded chaeta showing its squarish boss; (*H*) a chaeta showing partly abraded boss, but is otherwise similar to G; blade in both abruptly tapered and only slightly longer than the serrated distal end of chaetal shaft plus boss.

its bayonet-shaped collar chaetae similar. In *S. tetraceros*, on the other hand, the tube is white to light caramel coloured, obtusely triangular in cross-section, has a very low MLR and fine transverse growth markings extending laterally from it (Fig. 44A). Its operculum bears three main horns, of which the dorsolateral pair is branched thrice and the ventral horn is branched twice; the two branches of its dorsolateral horns are roughly equal to each other in size, as also are those of the ventral horn. The spines along the branches are somewhat longer, lighter in colour, not as chitinous and stiff as those in *S. semperi*. In its bayonet-shaped special collar chaetae (Fig. 45C,D), the serrated distal part of the chaetal shaft is shorter than the blade, and the boss is smoothly sloping rather than squarish. Inter-radiolar membranes are fringed (Fig. 45B).

Considering the sizes of the above two lots of specimens, there is every indication that *S. semperi* var. *acroceros* Willey is a juvenile form of *S. semperi*. There appear to be no significant differences between *Serpula quadricornis* Grube (1878: 275, pl. XV, fig. 6) and *Spirobranchus semperi* Mörch, 1861. Hence they are synonymized.

Spirobranchus sp. 5

Figs 58A–D, 59A–H

Material examined. Several specimens from Doom Island and Sop Island, Sorong, (0.50°S 131.17°E), West Irian (former Dutch West New Guinea), Indonesia; found growing on the tips of coral at 1–2 m depth, BMNH 1992.357–366, coll. by T.G.Pillai, 24 May 1971. According to label in jar: identified by ten Hove in 1988 as *S. tetraceros* (Schmarda).

Description

Measurements. Maximum external tube diameter, 2.0 mm; total lengths of worms, 9.7–8.6 mm; width of thorax 1.3–1.5 mm. Lengths of operculum and peduncle, 2.5–3.0 mm, opercular disc plus horns, 1.0–1.2 mm, and diameters of opercular plate, 1.5–1.6 mm. Abdominal lengths, 5.5–14.4 mm. Numbers of branchial radioles range from 12 per side to 17 on the left and 18 on the right.

Tube. Colour white; grows on coral (Fig. 58A), complete tube of a specimen, with much of coral newly laid over it removed, shown in latter figure; a row of transversely elongated chambers present ventrolaterally (Fig. 58B). Viewed from above (Figs 58C,D), has a low, more or less smooth MLR, and a flattened area on either side of it, the edge of the latter forming a lateral ridge. Obliquely transverse, smooth, shallow ridges and grooves on either side of the MLR may appear to be arranged in a row.

Worm. Operculum on left side, no rudimentary operculum on right; opercular plate circular, bearing three main horns; up to two main dichotomies may be present on each (Fig. 59B–D). Accessory spines at the end of and along the main branches: elongated, tapering, and mainly single. Fissures are present along the main branches, even extending into the dichotomies (Fig. 59C), apparently not having closed up as in other species. Peduncular wings unfringed (Fig. 59A,F). As seen in transparency through opercular peduncle of a post-juvenile specimen (Fig. 59F), a hollow is present ventrally, towards the centre of the opercular plate. Maximum number of 18 branchial radioles counted per side, arranged in a circle; their pinnule free tips being somewhat longer and thicker than the pinnules that precede them (Fig. 59E). Inter-radiolar membranes unfringed or bear a single papilla (Fig. 59A,D,E). Thorax consists of 7 chaetigers; apron present; abdominal uncinal tori lateral; two short pygidial papillae present (Fig. 59A).

Chaetae. Special collar chaetae bayonet-shaped, with a square boss in those that have not undergone abrasion (Fig. 59G), less squarish in partially abraded ones (Fig. 59H); their blades broad towards the boss, taper abruptly, and are only slightly longer than, or equal to length of serrated part of shaft plus boss. Uncini: saw-shaped; thoracic uncini with 12 or 13 teeth plus anterior gouge; anterior abdominal uncini with 8–10 teeth plus anterior gouge.

Remarks. *Spirobranchus* sp. 5 from from Sorong, Indonesia, is superficially similar to *S. tetraceros* from the Kimberleys, but there are important differences between them. Although the tubes in both are white, there are differences in their form. Tubes of adult *S. tetraceros* are obtusely triangular and bear only a single low, thin longitudinal ridge, the MLR. On the other hand, tubes of *S.* sp. 5 are less obtuse, more or less circular in cross-section, and bear not only a prominent and smooth MLR, but also a LLR at each dorsolateral angle of the trapezium. However, the opercular processes appear to be similar. The coral habit of *S.* sp. 5 (Fig. 58A), is similar to that described by Smith (unpublished thesis, 1985) for his *S. tetraceros* species B, from the GBR with the tubes following "sinuous paths between and along branches that are invested with coral skeleton."

Further work is necessary to determine whether the species that grows on coral tips in Sorong, Indonesia, belongs to *S. tetraceros* (Schmarda) or a new species.

Spirobranchus sp. 6

Fig. 60A–G

Material examined. BMNH 1972.250: one specimen with its tube, Tizard Bank, South China Sea, located between Vietnam and the Philippines, Bassett-Smith China collection; separated by H. Zibrowius in 1972 from a collection of *Dendrophyllia gravis*, BMNH 1889.9.24.16, in Coelenterata Section, presented by Lords of the Admiralty.

Description

Measurements. Maximum diameter of tube 2.5 mm; total length of worm 27.5 mm; length of operculum and peduncle 6.5 mm, length of operculum and its horn 2.5 mm, length of horn 0.6 mm, width of thorax 1.5 mm, length of abdomen 16.0 mm, number of abdominal segments about 115.

Tube. White, porous along sides, apparently caused by a boring sponge; a single simple, very low, median longitudinal ridge present.

Worm. Operculum arises close to the base of left radiolar crown, rudimentary operculum absent. Opercular plate circular, bears a somewhat dorsally located column which, in turn, bears three bifid horns, two of them dorsolateral, and the third ventral (Fig. 60A–D). Each dorsolateral horn has a pair of short pointed spines, located dorsolaterally, close to its tip, and another shorter spine, dorsally, almost at its tip (Fig. 60A–D). Lower branch of bifid dorsolateral horns, in turn, ends in a bifid spine with their tips pointing away from the opercular plate. Opercular peduncle elongated. Ventral horn ends in two spines, with their tips pointing away from the opercular plate. Peduncular wings unfringed (Fig. 60A–C). Number of radioles about 40 on each side, spirally arranged, with two whorls in each spiral; inter-radiolar membranes unfringed. Thorax has 7 chaetigers; apron present. Abdomen consists of about 115 segments.

Chaetae. Bayonet-shaped collar chaetae with distal part of the shaft, boss and blade serrated; the blade itself is 1½ as long as the combined length of the serrated distal part of the shaft and the boss in fully formed bayonet chaetae (Fig. 60E,F). Thoracic uncini saw-shaped, with 15 teeth arranged in a single row at one end of the (first) torus, and 11 at its other end, in addition to the anterior gouged process. Abdominal neurochaetae with flattened trumpet-shaped ends and long shafts projecting conspicuously beyond abdominal wall occur from first segment. Mid-abdominal neuropodia bear 2 or 3 chaetae with trumpet-shaped distal ends and one side drawn out into a tapering spine (Fig. 60G). Abdominal uncinal tori lateral; anterior abdominal uncini bear about 9 or 10 teeth, and posterior abdominal uncini about 10 or 11 teeth in addition to anterior gouge.

Remarks. *Spirobranchus* sp. 6 superficially resembles *S. richardsmithi*, but closer examination revealed the following important differences. The tube in *S. richardsmithi* possesses patches of mauve colour on a white to creamish background, being darker in some specimens that in others. As shown in Fig. 41A,J, it has 3 to 5 low longitudinal ridges. On the other hand, the tube in *S*. sp. 6 is white and bears a single, low, median longitudinal ridge only. Of the three horns arising from the central opercular column in *S. richardsmithi*, the dorsolateral pair is not dichotomously branched (Figs 41B–E,K,M,N; 42B,C,E,G); at the angle between the ventral and each dorsolateral horn, there is a short spine with its tip directed towards the opercular plate. The tips of the bifid ventral horn are also curved towards the opercular plate. On the other hand, the opercular horns in *S*. sp. 6 are very different. Firstly, all its three horns are bifid (Fig. 60A–D). Secondly, the lowermost spine on each dorsolateral horn is curved away from the opercular plate. Thirdly, tips of the bifid ventral horn are curved away from opercular plate. There appears to be a difference. In *S. richardsmithi* a maximum of 4½ whorls occurs in the branchial lobe of a specimen of total length 42.4 mm; 3½ spirals in a specimen of total length 24.0 mm. In comparison, the condition in *S*. sp. 6, of total length 27.5 mm, is intermediate between the latter two, its 40 or so radioles on each side are arranged in only two spirals. The maximum number of teeth in thoracic uncini also appears to be different, being about 17 or 18 in *S. richardsmithi* and only about 15 in *S*. sp. 3, in addition to the anterior gouged process.

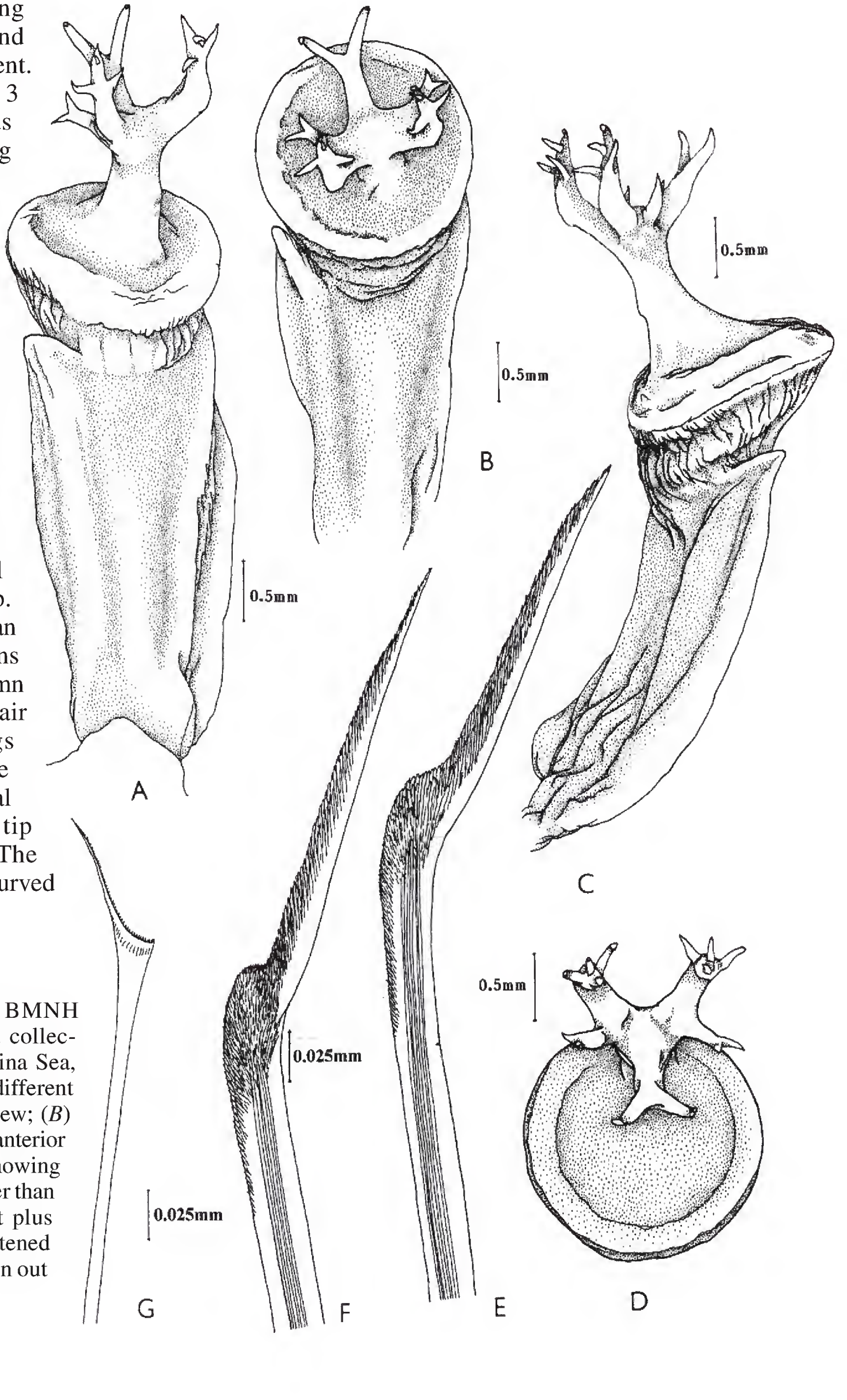

Figure 60. A–G, *Spirobranchus* sp. 6, BMNH 1972.250, Bassett-Smith South China Sea collection, Tizard Bank, located in the South China Sea, between Vietnam and the Philippines. A–D, different views of operculum: (*A*) left dorsolateral view; (*B*) anterodorsal view; (*C*) right lateral view; (*D*) anterior view; (*E,F*) bayonet-shaped collar chaetae showing the squarish boss and the chaetal blades longer than the serrated distal end of the chaetal shaft plus the boss; (*G*) abdominal chaeta showing flattened trumpet-shaped distal end and one side drawn out into a tapered process.

The above material appears to belong to a new species. However, further work on additional material would be needed in order to confirm whether the differences observed between the specimen from Tizard Bank and *S. richardsmithi* come within the scope of intraspecific variations of the latter or not.

Spirobranchus tenhovi n.sp.

Fig. 61B–H

Spirobranchus latiscapus.—Monro (1939: 152); *non* Marenzeller, 1885.

Material examined. BMNH 1941.3.3.1476, Tasmania, 41°03'S 148°42'E, 128 m, coll. B.A.N.Z.A.R. Expedition, 24 Mar. 1931. Consists of a mixed collection of orange-yellow tubes labelled *Spirobranchus latiscapus* (Marenzeller); easily mistaken to be a single species, but actually consists of two genera, as follows: 8 empty tubes belonging to a *Serpula crenata*-like species (Fig. 61A), and two specimens belonging to the genus *Spirobranchus*. One of the latter had the worm intact within its tube; in the other, the worm had been extracted previously from its tube, and was found lying loosely among the specimens. They were separated as holotype and paratype for the new species described below; and their respective registration numbers: NHM ANEA 2009.20., 2009.21.

Description

Measurements. Holotype: total length of tube, 48.0 mm; maximum width, 2.0 mm; maximum height, including fin-shaped extensions, 5.3 mm. Total length of worm, including its 2 stacked opercular plates, 34.5 mm; width of thorax, 3.0 mm; length of operculum and peduncle, 10. 2 mm; length of operculum, including its two discs, 1.0 mm; length of abdomen, 19.5 mm; number of abdominal segments, about 75.

Tube. Colour, yellowish-orange to orange and white; a light caramel to yellowish-brown longitudinal band present along base of MLR. Its shape is quite unlike that of any of the other known species of *Spirobranchus* (Fig. 61B); is 2½ times as high as it is wide at its anterior end, where the MLR is highest; latter sinuous, comparatively very high and consists of long conspicuous, fin-shaped forwardly directed processes of varying lengths (Fig. 61B). Two very low, thin lateral longitudinal ridges present on each side, one very close to base of MLR, and the other along its flank. Latter, well formed towards anterior part of tube, gradually becomes less so from its middle posteriorly (Fig. 61B). Along base of MLR, on either side of it, is a row of oblique, oval to elongated, forwardly directed foramina. Likewise, along either side of each LLR, at its base, is a row of similar foramina (Fig. 61B).

Worm. Operculum on left, no rudimentary operculum on right; conspicuously elongated (Fig. 61C–E), compared to that of the other "*S. latiscapus*-like" species dealt with in this account. Consists of well-formed stacked opercular plates, holotype with 2 (Fig. 61C,D); paratype with 4 (Fig. 61E); each opercular plate has a thin rim along its edge. Peduncular wings unfringed (Fig. 61D,E). Number of radioles in holotype, 33 on each side in holotype, arranged in a circle; inter-radiolar membranes short, about ¼ as long as the radioles, unfringed (Fig. 61F); pinnule-free tips of radioles slightly thicker than pinnules. Thoracic chaetigers number 7. Uncinal tori progressively increase in length posteriorly, leaving a clear inverted triangular area on ventral side of thorax; at ventral end of each uncinal torus there is dark pigment spot (Fig. 61G); apron present (Fig. 61G). Anterior abdominal tori short, located ventrolaterally. Long-shafted abdominal chaetae present throughout the abdomen, starting from about 2 segments from anterior end.

Chaetae. Bayonet collar chaetae (Fig. 61H) lack a squarish or pronounced boss; position normally occupied by boss hardly recognizable; gradually merges with blade. Distal part of chaetal shaft preceding boss: serrated (Fig. 61H), its length together with that of boss, about equal to that of blade. Uncini: saw-shaped; thoracic uncini with about 13 teeth, and anterior and posterior abdominal uncini about 11 and 13 teeth, respectively, in addition to the anterior gouge.

Remarks. *Spirobranchus tenhovi* n.sp. differs from *S. latiscapus* (Marenzeller, 1885) with regard to several characters, although the former was identified by Monro (1939: 152) as *S. latiscapus* (Marenzeller, 1885). Firstly, tube colour is yellowish-orange in *S. tenhovi*, and its shape is quite characteristic; its MLR consists of high wavy, fin-shaped sections, the most anterior one projecting forward conspicuously over the aperture. A row of oblique basal foramina is present on each side at the base of the MLR as well as at the base on either side of the two LLRs on each side. On the other hand, according to the original description of *S. latiscapus* by Marenzeller (1885), its tube colour is pinkish-red; it has longitudinal ridges bearing pointed processes or pointed lamellae, the MLR being the most prominent; sometimes only faint ridges present, frequently fine small spines or small pointed lamellae; sometimes only a single lateral ridge on each side. The special collar chaetae of *S. tenhovi* do not possess a prominent squarish boss, being hardly recognizable and merging smoothly between the shaft and the blade, unlike in *S. latiscapus*, where they possess a squarish boss.

According to the literature, it had previously been thought that there is a single species of *Spirobranchus* having stacked opercular plates, namely, *S. latiscapus* (Marenzeller, 1885). However, the present study shows that there is a group of species having stacked opercula belonging to the genus. They include *S. murrayi* and *S. tenhovi* described in this paper, as well as two more species, namely, *S. zelandicus* n.sp., and *S. zibrowii* n.sp., as seen below.

Etymology. Dedicated to Dr Harry A. ten Hove of the Institute of Systematics and Population Biology, Zoology Museum, University of Amsterdam, the Netherlands. We owe much of our current knowledge on the systematics, phylogeny and biology of serpulids to his many contributions, both individually and in collaboration with many colleagues, including the present author, working on the group, as well as to sharing his unpublished data with his colleagues in the search.for answers to problems concerning the taxonomy and relationships of serpulimorph polychaetes.

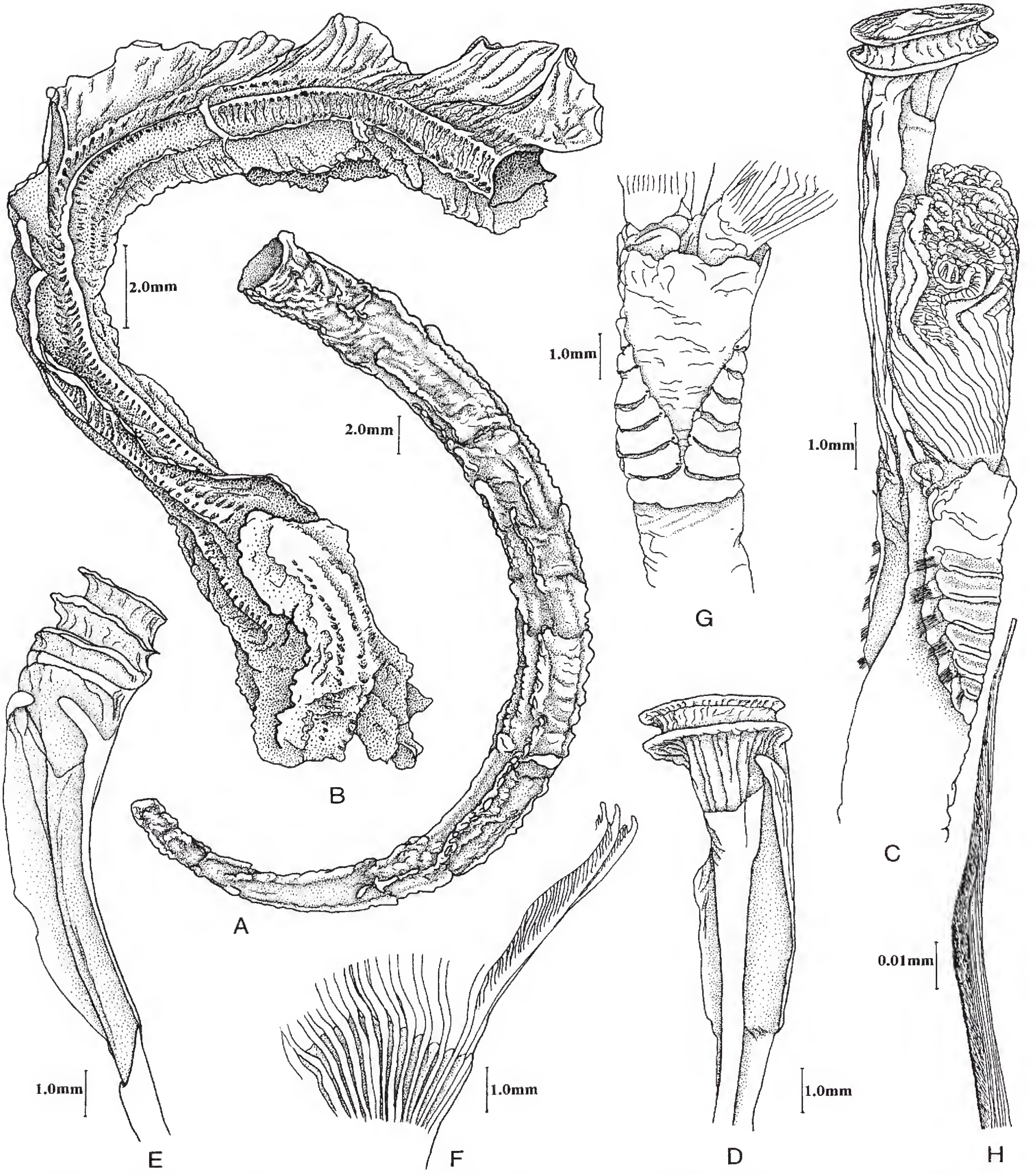

Figure 61. A–H, *Spirobranchus tenhovi* n.sp., BMNH 1941.3.3.1476, B.A.N.Z.A.R. Expedition, Tasmania Stn. 115, 128 m, labelled *Spirobranchus latiscapus* (Marenz.), but actually containing two genera/species. (*A*) one of the 8 orange coloured tubes of a *Serpula crenata*-like species mistakenly included with the new species of *Spirobranchus*, which also has yellowish-orange tubes. B–H, from holotype and paratype *of Spirobranchus tenhovi* n.sp; (*B*) tube of holotype (from which the worm was extracted during the present study); MLR high and consists of forwardly directed fin-shaped sections, most anterior one projecting conspicuously forward beyond the aperture; a row of oblique, forwardly-directed foramina present on either side, at its base. Two, low, narrow, LLRs present on either side of MLR; each also possesses a row of foramina on either side, at its base; (*C*) dorsolateral view of anterior end of holotype, with a two-tiered operculum; (*D*) ventrolateral view of latter; (*E*) left ventrolateral view of paratype showing its four-tiered operculum; (*F*) part of radiolar crown showing unfringed inter-radiolar membranes; (*G*) ventral view of thorax of specimen figured in C, showing a dark pigment-spot at the ventral end of each uncinal torus; (*H*) special collar chaeta; its boss is not squarish but merges gradually between distal end of chaetal shaft and blade; blade is longer than serrated distal part of chaetal shaft plus boss.

Spirobranchus zelandicus n.sp.

Fig. 62A–F

Spirobranchus latiscapus.—Monro (1939: 152); *non* Marenzeller, 1885.

Material examined. HOLOTYPE and PARATYPE: 2 specimens, of which one is an adult (holotype) and the other, a juvenile found located on the latter (paratype), New Zealand, BMNH 1936.2.8.3047–3048, coll. from *Discovery* station 941, 40°51.4'S 174°48.2'E–4°55.8'S 174°46.7'E, dredge, 128–0 m, 20 Aug 1932. Determined as *Spirobranchus latiscapus* (Marenzeller, 1885): by Monro, Discovery Report, 1936: 192, and according to the label on the jar. Their registration numbers: holotype, NHM ANEA 2009.20, and paratype, NHM ANEA 2009.21.

Description

Measurements. (Holotype) tube 9.7 mm high at aperture, including MLR; latter alone 3.0 mm high; maximum width at its base, 5.7 mm; and 5.5 mm at its sides. Total length of worm 26.9 mm, its thoracic width 2.6 mm; length of operculum and peduncle 8.0 mm; operculum only, 1.6 mm, and its diameter 3.5 mm; length of abdomen 12.8 mm; number of abdominal segments 93.

Tube. Tube surface of adult (holotype) and juvenile (paratype) covered over by a calcareous encrusting organism, with more or less transversely arranged apertures (Fig. 62A). Upon removal of encrustation, tube colour beneath, white, with a faint caramel colour along MLR and fainter colour along transverse ridges and flanks. Height of tube, greater than its width; MLR high, continuous, sinuous, partly divided into triangular fin-shaped sections, some with nearly pointed tips, and projects anteriorly over tube aperture as a thick, prominent, forwardly directed process (Fig. 62A). Ventrolateral parts of tube chambered in places where not attached to the substratum.

Worm. Operculum on left side; no rudimentary operculum on right. Opercular plate may either be tiered (4 plates) as in the holotype (Fig. 62B,C), or possess a single plate as in paratype (Fig. 62D,E). Viewed dorsally, opercular base and wings of juvenile broad and rounded laterally, and attached to the thorax by a comparatively narrow stalk (Fig. 62D,E). Peduncular wings unfringed (Fig. 62B,D). Radioles in holotype number 37 on the left and 36 on the right; apparently in one and a half spirals in their contracted condition, but actually in a circle. Inter-radiolar membranes unfringed. Collar: broad (Fig. 62B,D). Thorax has 7 chaetigers; apron present (Fig. 62B). Abdominal chaetae possess long shafts protruding from abdomen commencing about two segments from the anterior end; abdominal uncinal tori lateral (Fig. 62B).

Chaetae. Special collar chaetae bayonet-shaped; a long part of shaft serrated distally; boss elongated, with curved outline; blade narrower than shaft, tapering, its serrations extending to its tip, its length shorter than combined length of serrated distal part of chaetal shaft and boss (Fig. 62F). Thoracic uncini bear 12 or 13 teeth, and anterior abdominal uncini 9–11, in addition to the anterior serrated gouge. Anterior gouge characteristic: its sides pointed and directed outwards, while part in between is serrated (Fig. 62I,J). Abdominal chaetae like flattened trumpets distally, with one side drawn out into tapering process (Fig. 62G,H).

Remarks. *Spirobranchus zelandicus* n.sp., as shown in the present paper, is among a group of species belonging to the genus *Spirobranchus* that possess stacked opercula, although, according to several identifications in the literature, it was hitherto thought that there was only a single such species, namely, *S. latiscapus* (Marenzeller, 1885).

Evidently, a number of species similar to *S. latiscapus* have been identified as such merely on the basis of their stacked opercular plates. Among them is *S. zelandicus* n.sp., from New Zealand. It is similar to *S. zibrowii* from the Kimberleys in possessing a many-tiered operculum (Fig. 63E–J). However, the two species differ in the following respects. The tube of *S. zibrowii* is white to faintly bluish, and faint to darker-grey along the flanks. It has a high, thick, wavy MLR, which projects conspicuously beyond the aperture (Fig. 63A–D), and on either side of the MLR there is a very low, LLR. At the base of the MLR, as well as of each LLR, one either side of them, is a row small obliquely elongated foramina. On the other hand, the tube of *S. zelandicus* is white to faintly caramel coloured; and although it has a high, thick, MLR which projects conspicuously over the aperture as in *S. zibrowii*, it lacks LLRs and the rows of foramina characteristic of the latter (Fig, 62A). The operculum in *S. zibrowii* bears 2 to about 4 irregularly or incompletely formed and eccentrically laid plates, which may be on a short cylindrical column (Fig. 63E–J), and its opercular peduncle is fringed. On the other hand, the opercular plates in *S. zelandicus* are more regularly formed, and its peduncular wings are unfringed (Fig. 62B–E). The special collar chaetae of *S. zibrowii* are not bayonet-shaped, the distal part of the chaetal shaft is unserrated and a boss is absent (Fig. 63K), whereas, those of *S. zelandicus* are bayonet-shaped, possess a long serrated area, about as long as the blade itself, and prominent boss (Fig. 62F). Both *S. zibrowii* and *S. zelandicus* are different from *Spirobranchus latiscapus* (Marenzeller, 1885) and other species described in this paper in several respects, including tube colour and form and chaetae.

According to ten Hove (1994: 113), *S. latiscapus* has a wide Indo-West Pacific distribution, including New Zealand, and generally occurs below a depth of 50 m. Smith (unpublished thesis, 1985), deals with the *S. latiscapus* (Marenzeller, 1885) complex. The type locality of *S. latiscapus* is in Japan, near Eno-shima, Naze, Oshima (Marenzeller, 1885: 218–219). It was described under the genus *Pomatostegus* Schmarda, 1861. Benham (1916: 158–159) transferred *Pomatostegus latiscapus* Marenzeller, 1885 to the genus *Spirobranchus* mentioning among others, that its operculum "is calcareous instead of being of horny material." Takahasi (1938: 215) also deals with it as *Pomatostegus latiscapus*, but earlier Benham (1916) showed it to be a *Spirobranchus*.

Based on the original description of *S. latiscapus* by Marenzeller (1885: 218–219), its tube colour is pinkish-red; slightly triangular in cross-section, and has a median longitudinal ridge and one to several lateral longitudinal ridges bearing pointed processes or lamellae. Median longitudinal ridge is the most prominent. Sometimes only faint ridges present, or only a single lateral longitudinal ridge on each side, frequently only fine small spines or small pointed lamellae. Although Marenzeller had several specimens, the only complete had a total length of 27.5 mm (21.0 mm without its radioles), its operculum and peduncle 6.5 mm. Operculum on left, the number of stacked opercular

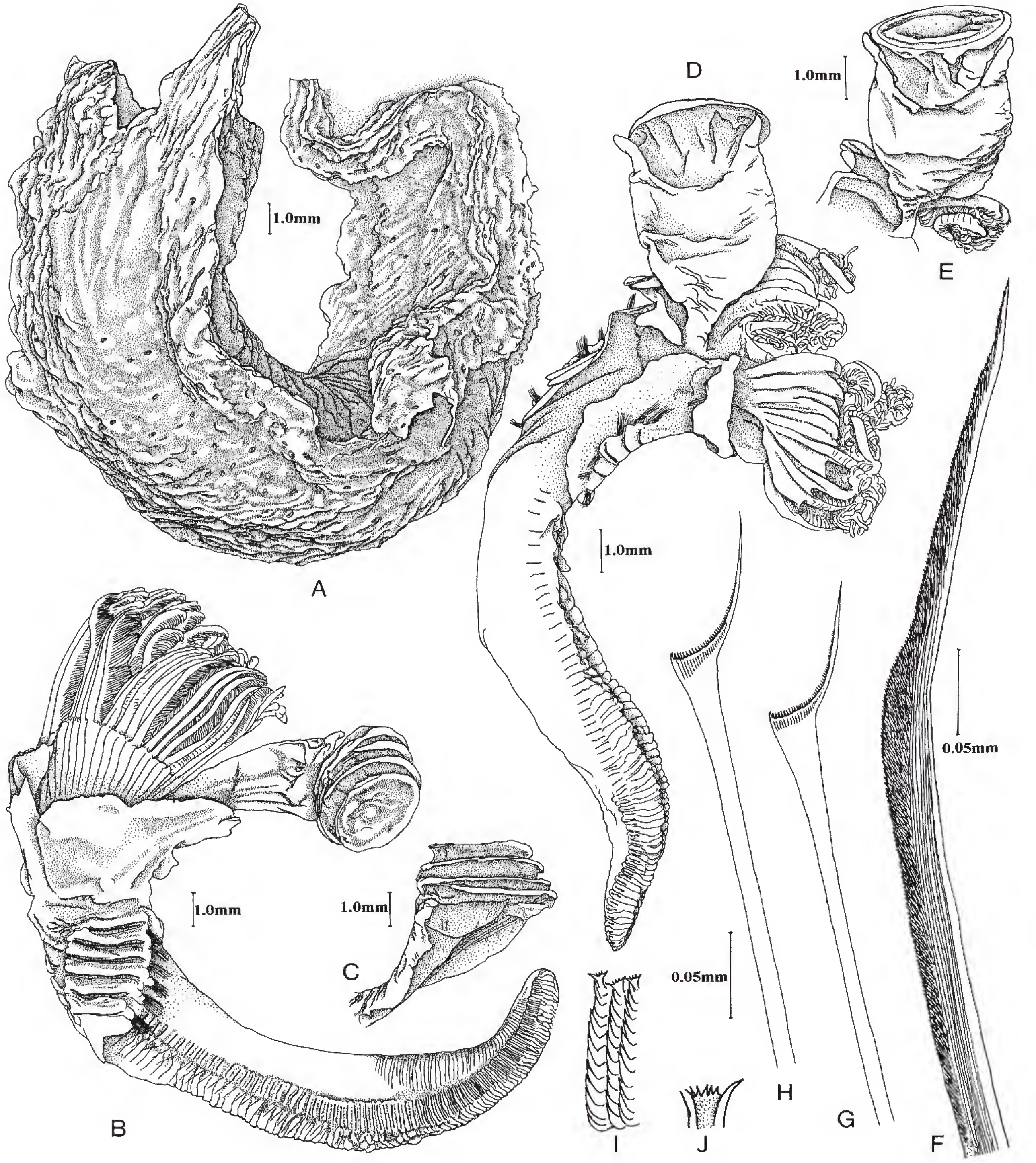

Figure 62. A–J, *Spirobranchus zelandicus* n.sp., BMNH 1936.2.8.3047–3048, Two specimens, from New Zealand, *Discovery* Expedition Stn. 941, collected on 20.08.1932. (*A*) tube of holotype, with tube of a juvenile, paratype, on it. Both are covered over by a thin calcareous encrusting organism having scattered foramina over its surface. A high median longitudinal ridge ends in a conspicuous stout tooth projecting forwards over the aperture in the adult (holotype); yet to be formed in the juvenile tube (paratype); (*B*) whole worm (holotype), showing its 4-tiered operculum, unfringed inter-radiolar membranes, wide collar and long-shafted abdominal neurochaetae; (*C*) another view of the 4-tiered operculum of the holotype; (*D*) whole worm (paratype) with its single-tiered operculum, un-fringed peduncular wings and inter-radiolar membranes; (*E*) operculum of the paratype, another view; (*F*) bayonet-shaped special collar chaeta showing its boss and the long serrated part of the chaetal shaft preceding the boss. The gradually tapering blade is shorter than the serrated distal part of the chaetal shaft plus boss; boss is not squarish, yet recognizable, smoothly rounded and considerably narrower than blade; (*G,H*) distal ends of abdominal neurochaetae; (*I*) thoracic uncini showing serrated gouge; (*J*) enlarged view of serrated gouge.

plates 4, peduncular wings unfringed. Number of radioles, presumably on each side, 25, arranged in a circle. In another specimen, the operculum and peduncle was 8.5 mm long, its operculum alone, 2.5 mm, and it consisted of 6 stacked plates; their number in all his specimens ranged from 3–7. Thoracic chaetigers numbered 7. Bayonet collar chaetae described as having a squarish boss; and thoracic uncini as having a dozen teeth.

Monro (1936: 192) identifies the above material from "Discovery" Station 941 off New Zealand, as *S. latiscapus* (Marenzeller, 1885). It is, however, described as a new species, *S. zelandicus* in the present account. Although Monro does not describe its tube, the following data are provided with regard to the worm. A larger specimen is about 23 mm long, its width 3.0 mm; operculum consists of 1 to 5 thin stacked calcareous plates; special collar chaetae described as "with a short wide striated fin-like process at the base of the narrow anterior blade" and the thoracic uncini as having about 12 teeth in addition to the basal gouge. Monro's description of the bayonet collar chaetae as having a fin-like process at the base of the blade appears to be due to a misinterpretation of the chaetal structure. As shown in the present study of several species of *Spirobranchus*, the special collar chaetae could range from being bayonet-shaped and possessing a squarish basal boss, to those in which the boss is reduced to various extents and even in being completely absent, but a fin-like process does not occur in *Spirobranchus*. The part of the bayonet chaeta described by Monro as being fin-like is, therefore, the boss at the distal end of the chaetal shaft. The descriptive term "fin-like" is used for that fin-shaped part of the bayonet collar chaeta that is separated from the rest of the blade in certain other genera as, for example, *Filograna* Oken, 1815 among Serpulidae, and *Spirorbis* Daudin, 1800 among Spirorbidae (*vide* Knight-Jones & Knight-Jones, 1977).

Spirobranchus zelandicus differs from *S. latiscapus* (Marenzeller) in the following respects. The tube in the former is white to cream coloured, has a high, thick, wavy MLR, which projects conspicuously over the aperture, but lacks LLRs. In contrast, that in *S. latiscapus*, as described by Marenzeller (1885), is pinkish-red and has not only a MLR, but usually also LLRs, all usually bearing pointed processes or lamellae. Special collar chaetae of *S. zelandicus* possess a smoothly elongated non-squarish boss, whereas that of *S. latiscapus* is squarish.

Etymology. Named after its type locality, New Zealand.

Spirobranchus zibrowii n.sp.

Fig. 63A–L

Material examined. SYNTYPES: BMNH 1959.10.19.25–28 and BMNH 1959.10.19.22/24, from Cronulla, New South Wales, Australia, collected and determined as *Pomatostegus polytrema* (Philippi) by B. Dew. Two vials containing several fragments and 10+ worms and detached opercula. According to a note by H. Zibrowius in 1973 with syntypes, it is a new species of *Pomatoceros*. AM W3578, a large cluster of tubes about 6.0 cm in diameter, 25 specimens, Blackhead, Gerroa, New South Wales, Australia, 34°36'S 150°50'E, coll. E.C. Pope, 15 Sept. 1947; according to notes with collection: determined as *Pomatoceros* sp. by Dew; a new species by H. Zibrowius in 1973, and by H.A. ten Hove. AM W3635, 1 specimen, and AM W5637, 12 specimens, all from Hungry Point, Cronulla, New South Wales. Australia, 34°04'30"S 151°08'48"E, collected by B. Dew, 6 Oct 1956. A note by H. Zibrowius states that this was to be described as a new species, *Spirobranchus australis*. AM W3917, 1 specimen, Long Reef, west end of reef, 33°44'S 151°19'E, collected by D. Straughan, 27 Jan. 1964, and, according to notes with collection, determined by D. Straughan as *Temporaria polytrema*, but a new species by H. Zibrowius in 1972. AM W3918, 2 specimens, Vincentia, Jervis Bay New South Wales, Australia, 35°04'30"S 151°41'0"E, coll. by D. Straughan, 26 Jan. 1964, and, according to notes with collection, determined as *Temporaria polytrema* by D. Straughan, but considered a new species by H. Zibrowius in 1972. AM W23503, 2 specimens + 3 empty tubes, Cronulla, New South Wales, Australia, 34°04'S 151°09'E, according to note with collection, determined by H.A. ten Hove as belonging to same species considered to be new by H. Zibrowius in 1972. AM W23500, 7 specimens, Bottle and Glass Rocks, Port Jackson, New South Wales, Australia, 33°50'54"S 151°09'E, 1 Nov. 1955, according to note with collection, determined by ten Hove as belonging to a new species. AM W23502, 1 specimen, Cronulla, New South Wales, Australia, 34°04'S 151°09'E, 1 Nov 1955. AM W23501, 2 specimens, Hungry Point, Cronulla, New South Wales, Australia, 34°04'30"S 151°08'48"E, 15 Aug 1950, examined by ten Hove & labelled as the same new species as intended to be named by H. Zibrowius as *Pomatoceros australis*.

Description

Tube. In syntypes, colour white to faintly bluish, with faint to darker bluish-grey along flanks, much lighter or white along flanges. Triangular in cross-section with a wide flange on each side (Fig. 63A–D); MLR high, continuous, sinuous, and projects forward quite conspicuously over aperture; a very low LLR present on either side of MLR. A row of obliquely elongated to oval foramina present on either side of MLR, at its base; likewise, a row of foramina present on either side of each LLR, at its base (Fig. 63A,B); moreover, another row of foramina, present along each flank of the tube. Variations occur, (Fig. 63C,D), where the LLR may be reduced in places and only foramina may be irregularly present. Shallow, anterolaterally-directed grooves alternate with low ridges along the lateral flanges (Fig. 63A,B); flanges usually obliquely chambered (Fig. 63C).

Worm. Syntypes poorly preserved, brittle, apparently having dried up and re-introduced into alcohol. Operculum is on left side, no rudimentary operculum on right; bears 2 to a few obliquely stacked plates; most distal plate may be considerably smaller in diameter than basal plate, and separated from rest by a short irregular cylindrical column (Fig. 63E–H). In a third specimen two plates present, including basal plate, eccentrically attached (Fig. 63I,J); a translucent rim present on each terminal plate; a granular calcareous overlay seen when illuminated from certain angles (Fig. 63G–I). Peduncular wings apparently fringed in a specimen which shows 3 papillate processes on one side (Fig. 63J).

Chaetae. Bayonet collar chaetae do not possess a squarish boss; instead, it appears to be elongated, gradually sloping and merging with a slender tapering blade (Fig. 63K); in lateral view, about half-way from proximal end of blade, clear part of the latter considerably narrower than serrated area (Fig. 63K); distal part of chaetal shaft apparently unserrated; or, perhaps, indistinguishable from serrated blade; chaetae accompanying special collar chaetae of similar length but more slender (Fig. 63L). Thoracic, anterior and posterior abdominal uncini saw-shaped, bearing only about 8 or 9 teeth, besides anterior gouged process; two sides of latter pointed. Abdominal neurochaetae with long shafts protruding conspicuously from beyond body wall present along almost entire length of abdomen, commencing from about 2 or 3 segments from anterior end; their flattened

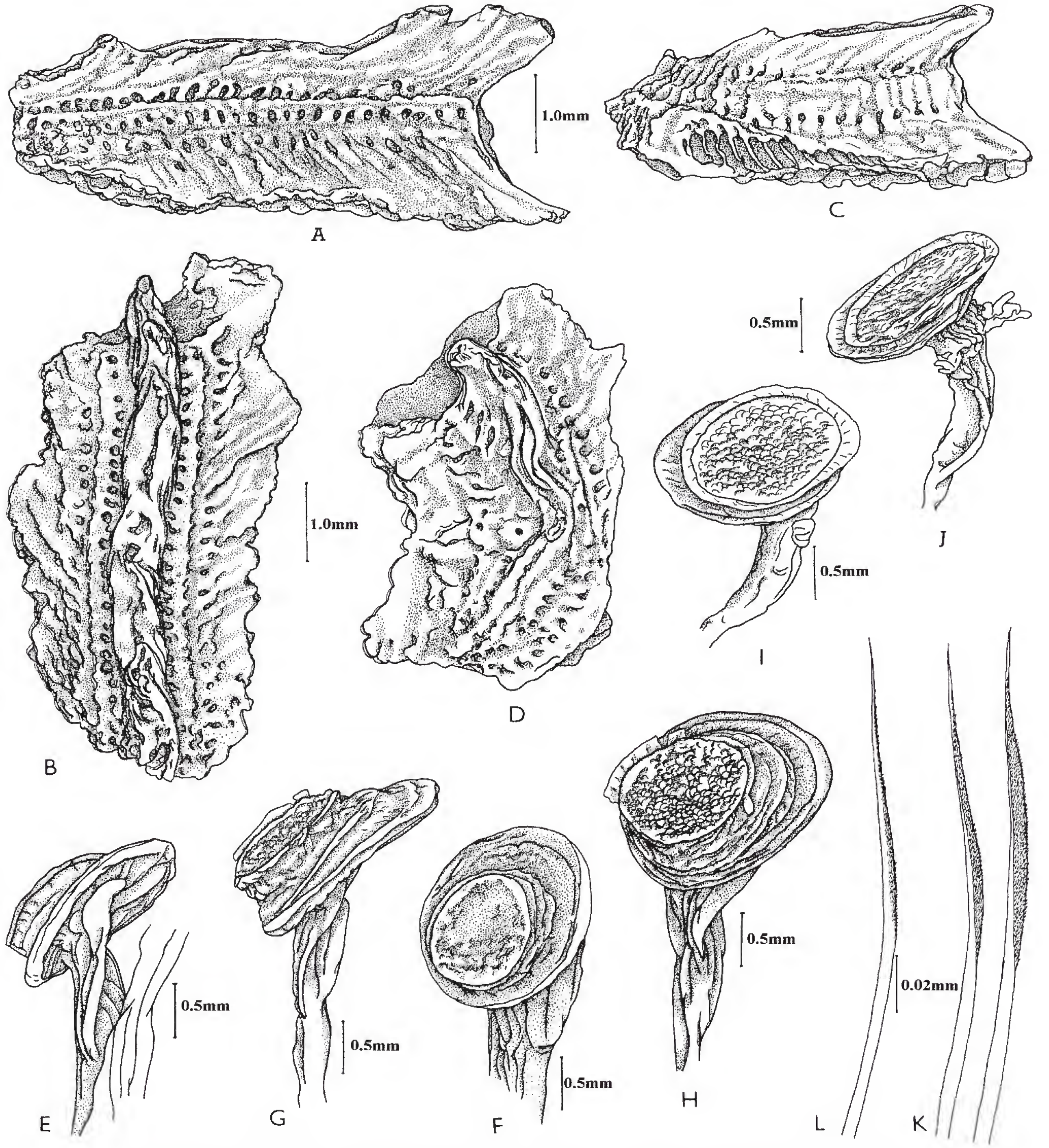

Figure 63. A–J, *Spirobranchus zibrowii* n.sp.: BMNH 1959.10.19.25–28: From specimens collected from Cronulla, NSW Australia, identified as *Pomatostegus polytrema* (Philippi) and presented by B. Dew. (*A,B*) two lateral views of a tube; (*C,D*) two dorsal views of another tube; (*E,F*) two views of operculum of a specimen; (*G,H*) two views of operculum of another specimen; (*I,J*) two views of operculum of a third specimen; (*K*) special collar chaetae: its shaft lacks a distal serrated area and its boss appears to be elongated and merges gradually with a reduced blade; (*L*) a "capillary" chaeta found together with the special collar chaetae; it is slender compared to the latter, but otherwise similar.

trumpet-shaped ends have one side drawn out into a tapering spine. Abdominal uncinal tori: short and lateral.

Remarks. It would be useful to include some notes on examination of additional material since the syntypes are not well preserved. AM W3578 consists of a large cluster of about 6.0 cm in diameter, with numerous intertwined mutually bonded tubes. They are mostly bluish-grey. Tube lengths in such clusters are difficult to determine. Ridges and foramina are as in those observed in the BMNH sample described above, but mostly lacking LLRs. while the associated foramina are very poorly developed or altogether missing along most of the tube. In one of the larger specimens, total length of worm is 26.8 mm; width of thorax 2.0 mm; length of operculum and peduncle 4.6 mm; length of operculum 2.6 mm and length of abdomen 19.2 mm.

In AM W3635, tubes mostly white, few with light bluish-grey along the flanks; maximum width of one of the largest tubes 7.0 mm, including the lateral flanges, 4.2 mm without the flanges. Operculum occurs on left side; no rudimentary operculum on right. Many opercula possess a single concave disc. Radiolar arrangement circular, with 21 left side; 22 on right. Number of abdominal segments: about 88. Chaetae similar to those described above; long-shafted flattened trumpet-shaped neurochaetae present throughout the abdomen, starting from about 2 or 3 segments from anterior end.

Although specimens having two or more eccentric discs are included under the present new species, those in AM W3635 mostly possess opercula consisting of a single concave opercular plate. They appear to be somewhat similar to that of *Spirobranchus* sp. 2 described earlier from Eden. Unfortunately, the single specimen of *Spirobranchus* sp. 3 lacks its tube. Further studies are necessary to determine whether it is similar to that of *S. zibrowii.*

Both H. Zibrowius and Harry ten Hove (pers. comm.) suggested that the present author describe the present species, since it was unlikely that they would deal with it owing to their ongoing research commitments.

Etymology. It is named after Dr H. Zibrowius, formerly of Station marine d'Endoume, Marseille, who, in his study of the above specimens in Natural History Museum, and in an unpublished manuscript, considered it a new species; also in appreciation of his numerous contributions to our knowledge on serpulimorph polychaetes.

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Appendix

Key to genera and species from the Kimberleys and elsewhere in the Indo-West Pacific dealt with in present paper.

1 Operculum absent 2

—— Operculum present 4

2 Number of thoracic chaetigers 10 .... *Kimberleya hutchingsae* n.gen. & n.sp.

—— Number of thoracic chaetigers 7 3

3 Apron present .... *Protula bispiralis* (Savigny, 1820)

—— Apron absent .... *Pseudoprotula kimberleyensis* n.gen. & n.sp.

4 Operculum chitinous 5

—— Operculum calcareous .... genus *Spirobranchus* Blainville, 1818 21

5 Operculum cylindrical or conical, divided into a number of partitions 6

—— Operculum consists of other forms 7

6 Opercular diameter greater than height, maximum number of partitions: about 4 or 5 .... *Vermiliopsis cylindrica* n.sp.

—— Opercular height less than diameter, conical, maximum number of partitions numerous .... *Vermiliopsis glandigera* Gravier, 1908

7 Operculum consists of a central column bearing a series of saucer-shaped discs and circles of spines .... *Pomatostegus actinoceros* (Mörch, 1963)

—— Operculum consists of other forms 8

8 Operculum consists of a funnel-shaped structure (infundibulum) surmounted by a corona (or verticil) of characteristic processes .... genus *Hydroides* Gunnerus, 1768 9

—— Operculum consists of an infundibulum only 17

9 Corona consists of six roughly diamond-shaped swollen processes, one larger than the rest, their tips curved towards the centre, and each bearing a short triangular spine on each shoulder; infundibulum cup-shaped, its marginal lobes end in T-shaped to crescentic tips .... *Hydroides adamaformis* n.sp.

—— Corona and infundibulum consist of other forms 10

10 Corona consists of up to about 10 tapered spines, the most dorsal one larger than the rest, their tips curved towards centre of crown, and the rest curved outwards; infundibulum funnel-shaped, its radii ending tapered outwardly curved tips .... *Hydroides exaltatus* (Marenzeller, 1885)

—— Corona and infundibulum consist of other forms 11

11 Corona consists of 5 similar triangular processes, each bearing medially at its base about 4 or 5 tiny spines, and ending distally in a transparent bluntly pointed transparent anteriorly directed tip; its marginal lobes minute, acutely triangular, their tips outwardly curved .... *Hydroides kimberleyensis* n.sp.

—— Corona and infundibulum consist of other forms 12

12 Corona consists of usually 7, sometimes 6, processes, all of them devoid of basal spines; most dorsal process stout, elongated, and terminates in 3 sharply pointed hooks, one of the latter curved ventromedially and the other two posterolaterally; the remaining coronal processes simple, short, outwardly curved; infundibulum obtusely funnel-shaped, its radii end in simple, somewhat swollen to T-shaped processes .... *Hydroides minax* (Grube, 1878)

—— Corona and infundibulum consist of other forms 13

13 Coronal processes, including the modified one, lack medial processes; marginal infundibular processes end in swollen to T-shaped tips; bayonet shaped collar chaetae possess a very long unserrated notch, about ⅓ length of blade, and the 2 teeth at base of blade way down along the boss, unlike in *H. exaltatus* .... *Hydroides pseudexaltatus* n.sp.

—— Corona and infundibulum consist of other forms 14

14 Corona consists of 7 processes, of which the most dorsal one is vesicular, shaped like a swollen beak, curved towards centre of crown; remaining processes highly reduced, pressed against base of modified processes, their bases broad, and their short simple pointed tips directed outwards; infundibulum a short funnel, its radii pressed against the base of corona, their simple black tips directed outwards .... *Hydroides simplidentatus* n.sp.

—— Corona and infundibulum consist of other forms 15

15 Corona consists of 6 or 7 similar tapering spines, firstly directed anteriorly and inclined towards the centre, then curved outwards before ending in outwardly curved black, pointed, tips. Each spine also bears a medial spine and a basal spine, which sharply curved towards the base, as well as a pair of outwardly directed spines. Infundibulum funnel shaped, each of its marginal processes has a sub-terminal knee-like bend beyond which it tapers and ends in a simple, pointed, outwardly curved process .... *Hydroides spiculitubus* n.sp.

—— Corona and infundibulum consist of other forms 16

16 Corona consists of 9 processes, most dorsal of which is vesicular and anteroventrally directed, with a dorsolateral extension on either side, which gives it a T-shaped appearance in anterior view; remaining coronal spines simple, end distally in somewhat T-shaped tips. Infundibulum-funnel-shaped, its radii end distally in swollen to T-shaped tips .... *Hydroides spiratubus* n.sp.

—— Corona consists of several, at least 11–15, processes, all outwardly directed and devoid of basal processes; most dorsal spine larger than rest, ends distally in a pair of dorsolaterally directed processes and a medial pointed beak-like swelling; tips of remaining coronal spines T-shaped, ends of latter pointed. Infundibulum, a short obtuse funnel, its radii end in T-shaped tips; ends of latter pointed .... *Hydroides trihamulatus* n.sp.

17 Operculum usually consists of a funnel-shaped infundibulum, bearing a number of radii separated by interradial grooves and ending in marginal lobes. Internal tube structures present .... *Spiraserpula snellii* Pillai & ten Hove, 1994

—— Operculum usually consists of a funnel-shaped infundibulum, bearing a number of radii separated by interradial grooves and ending in marginal lobes. Internal tube structures absent ...... genus *Serpula* Linnaeus, 1758 18

18 Operculum bell-shaped, lacks a central hollow, its proximal part swollen, distally bears a comparatively small number of, about 17, broad, rounded, radial lobes with thick translucent cuticle; tubercles absent; a sharp constriction between operculum and peduncle .... *Serpula amplilobata* n.sp.

—— Operculum has other forms 19

19 Operculum an elongated funnel bearing distally numerous sub-triangular radial lobes with blunt tips; tubercles present along radii; lacks a sharp constriction between operculum and peduncle .... *Serpula jukesii* Baird, 1865

—— Operculum has other forms 20

20 Operculum funnel-shaped, its distal part circular, bearing numerous sub-triangular marginal lobes with blunt tips and thin transparent cuticle; tubercles absent along radii; proximal part like an inverted cone, decreasing in diameter posteriorly, then becoming bulbous before it joins the peduncle; a sharp constriction between operculum and peduncle .... *Serpula nudiradiata* n.sp.

—— Operculum funnel-shaped, possesses a central hollow; distally a moderately large number, up to about 30, bluntly triangular to squarish marginal lobes, with thin translucent cuticle; proximal part of operculum swollen; a sharp constriction present between operculum and peduncle .... *Serpula watsoni* Willey, 1905

21 Opercular processes consist of 8 consist of 8 conspicuously long spines, each bearing a row of, usually 3 or 4, somewhat elongated, pointed, unbranched, medial spines, with their tips medially curved, and short unbranched lateral spines, which may, in turn, bear 2 or 3 smaller spines; at their centre is a very short, dichotomously branched horn; opercular plate circular .... *Spirobranchus baileybrockae* n.sp.

—— Operculum has other forms 22

22 Opercular processes usually consist of a pair of horns borne on a common base and arising posteriorly from the opercular plate; each horn bears a short bifid dorsomedial spine towards its base, a short posterolateral spine towards its middle, and ends in a bifid tip; latter often wasted through abrasion against tube; opercular plate oval, wider anteriorly than posteriorly .. *Spirobranchus corniculatus* (Grube, 1862)

—— Operculum has other forms 23

23 Opercular processes consist of a pair of bluntly conical processes arising from opercular plate, and inclined posterodorsally; opercular plate circular .... *Spirobranchus* sp. 1, cf. *polytremus* (Philippi, 1844)

—— Operculum has other forms 24

24 Opercular processes consist of a short and stout or comparatively longer and less stout column bearing distally a pair of dorsolateral horns and a ventromedian horn; each dorsolateral horn ends in an anteroventrally curved, more or less pointed tip; dorsolateral horns not dichotomously branched; a short spine occurs at angle between ventral and each dorsolateral horn; its tip is directed towards the opercular plate; tips of bifid midventral process also curved opercular plate; each dorsolateral horn also bears 3 short accessory spines, one ventrolaterally towards its middle, the other two subterminally; opercular plate circular. Tube colour ranges from yellowish to yellowish brown and light mauve; in latter mauve patches on a white background .... *Spirobranchus richardsmithi* n.sp.

—— Operculum has other forms 25

25 Opercular processes consist of apparently 4, but really 3, dichotomously branched horns arising from a common base, two of them dorsolateral and the third ventral; dorsolateral horns branched thrice, ventral horn branched twice; opercular plate circular. Tube white, obtusely triangular in cross-section, with an insignificant, low, MLR .... *Spirobranchus tetraceros* (Schmarda, 1861)

—— Operculum has other forms 26

26 Opercular process a short conical, pitted cap, arising from a circular plate; distal end slanted dorsally, lacks processes .... *Spirobranchus* sp. 2 (juveniles)

—— Operculum has other forms 27

27 Opercular process consists of an acute cone having a number of annuli; opercular plate circular .... *Spirobranchus acuiconus* (Pillai, 1960)

—— Operculum has other forms 28

28 Opercular processes consist of up to about 4, of variable length, which may bear short lateral processes; opercular plate circular, flat to dome shaped. Tube light to bright pink, or pinkish red to brownish mauve; a very high, wavy, MLR present, more or less continuous in some places, interrupted or broken off in other places .... *Spirobranchus arabicus* n.sp.

—— Operculum has other forms 29

29 Operculum lacks processes; opercular plate circular; bears a narrow, transparent rim .... *Spirobranchus* sp. 3

—— Operculum has other forms 30

30 Operculum conical, its apex dorsally curved and bearing vestiges of 3 dichotomously branched horns, ending in a few transparent spines; opercular plate circular, flat to dome shaped. Tube light to bright pink or pinkish-red to brownish-mauve; a very high, wavy, MLR present, which projects conspicuously aperture; gently sloping overture; gently sloping laterally, bears an LLR on either side; longitudinal rows of foramina absent. Chaetal boss conspicuously squarish, distal part of shaft serrated all round .... *Spirobranchus elatensis* n.sp.

—— Operculum has other forms 31

31 Operculum lacks processes; opercular plate circular, flat to concave, lacks processes. Tube bluish-grey to white, triangular in cross-section, chambered along in lateral flanges, bears a low to high MLR, which frequently extends as a flattened to pointed process over aperture .... *Spirobranchus kraussii* (Baird, 1865)

—— Operculum has other forms 32

32 Operculum bears 3 main dichotomously branched, translucent processes, two dorsolateral and the third ventral; usually branched twice, sometimes dorsal processes branched thrice; a single medial spine located at or below second dichotomy, followed by 1, 2, or 3 along each branch; opercular plate circular, somewhat dorsoventrally oval; tube unknown .... *Spirobranchus* sp. 4

—— Operculum has other forms 33

33 Operculum lacks processes; opercular plate circular, flat to somewhat concave, bears circular concentric markings which decrease in diameter towards centre (not scars of left over from broken off spines). Tube caramel brownish or faintly pinkish in colour, with slightly darker pink along MLR; latter prominent, somewhat sinuous, with conspicuous forwardly directed projections, low anteriorly, may be triangular along middle of tube, or end in laterally flattened, stumpy tips, as if they were, apparently, broken off .... *Spirobranchus maldivensis* Pixell, 1913

—— Operculum has other forms 34

34 Operculum 1 to at least 3 stacked circular plates; latter plus peduncle about as long as long as abdomen in preserved material; peduncle and wings transparent, triangular; peduncular wings unfringed .... *Spirobranchus murrayi* n.sp.

—— Operculum has other forms 35

35 Opercular processes consist of 3 horns arising from a short, stout stem, 2 of them dorsolateral, and the 3rd ventral; dorsolateral horns horn shaped, curved outwards and ventrally; each dorsolateral horn bears along its lateral edge, a groove covered by a chitinous layer, may also bear a small knob dorsomedially, at its base; ventral horn tallest of three, projects conspicuously anteroventrally, then curved anteriorly, and ending in two outwardly curved branches; each of latter may, in turn, be dichotomously branched once or twice to give rise to short outwardly curved processes. Tubes white, mutually boded, their shape quite characteristic when unhindered by competing individuals in same clump; obtusely triangular in cross-section; initially a low MLR, which abruptly develops 1 to about 5 massive teeth, the most anterior of which projects over tube aperture; depending on competing individuals, most anterior process may be pointed, somewhat flattened, or like a cobra's hood directed anteriorly or laterally .... *Spirobranchus paumotanus* (Chamberlin, 1919)

—— Operculum has other forms 36

36 Operculum conical, its peak usually dorsally curved, sometimes a short, cylindrical stump. Tube triangular in cross-section, wide anteriorly, but rapidly narrows posteriorly; bears a smooth, irregularly formed MLR, which ends anteriorly as a small, low, tooth over aperture; an irregularly formed row of foramina present at the base on either side of MLR; an irregularly formed, low, narrow LLR present on either side of MLR; a row of irregularly formed foramina present on both sides of base of each LLR .... *Spirobranchus pseudopolytremus* n.sp.

—— Operculum has other forms 37

37 Opercular processes consist of 4 stiff horns, of which 2 are dorsal and 2 ventral; dorsal pair longer than ventral pair; each dorsal horn bears only a short dorsomedial branch, ventral horns unbranched; very short, stiff spines occur along branches, simple medially, mostly bifid dorsally; opercular plate circular, more or less flat. Tube has an overall pink colour, in parches on a white background; bears a prominent, thick, raised, wavy MLR, which projects as a small tooth over aperture; a very faint, smooth MLR may be discernible in places; a wide lateral flange present in places .... *Spirobranchus semperi* Mörch, 1861

—— Operculum has other forms 38

38 Opercular processes consist of 3 main horns, of two located dorsolaterally and the third ventrally; up to 2 dichotomies present in each horn; accessory spines along and end of horns, acutely triangular, elongated, tapering, mainly single; fissures present along main branches, even extending along dichotomies; opercular plate circular. Tube white, quadrilateral in cross-section, bears a low, more or less smooth MLR; area on either side of latter flattened, edge of latter forming a lateral ridge; tube chambered ventrolaterally, the chambers transversely elongated .... *Spirobranchus* sp. 5

—— Operculum has other forms 39

39 Opercular processes consist of a single, dorsally located column, the end of which bears 3 bifid horns, 2 of them dorsolateral, the 3rd ventral; each dorsolateral has, close to its tip, 2 short pointed spines, and another shorter spine almost at its tip; lower branch of bifid lateral horns, in turn, ends in a bifid spine, with their tips pointing away from the opercular plate; ventral horn ends in 2 spines, their tips pointing anteriorly, i.e., away from opercular plate rather than towards it. Tube white, bears a very simple, low MLR .... *Spirobranchus* sp. 6

—— Operculum has other forms 40

40 Opercular processes of up to about 4 stacked plates with a thin rim along its edge; peduncle conspicuously elongated. Tube quite characteristic; its colour yellowish-orange to orange and white; a light caramel to yellowish-brown longitudinal band present along base of MLR; shape of latter quite unlike that of hitherto known species of the genus; where MLR is highest, at its anterior end, it is 2½ times as high as wide, and consists of sinuous, fin-shaped forwardly directed processes of varying lengths; 2 very low, thin, LLRs present on each side, one very close to base of MLR, and the other flank; along either side of base of MLR is a row of oblique, forwardly directed foramina; likewise, along either side of base of each LLR, is a row of similar foramina .... *Spirobranchus tenhovi* n.sp.

—— Opercular processes consist of 1 to a few obliquely superimposed, eccentrically attached plates; most dorsal plate may occur at end of a short, oblique column. Tube white to faintly bluish, with faint to darker grey along flanks, much lighter to white along flanges ; triangular in cross-section, with a wide flange on each side; MLR high, sinuous, projects conspicuously over aperture; a very low LLR present on either side of MLR; on either side at the bases of MLR, and each LLR, is a row oval to obliquely foramina; furthermore, there is a row of foramina along each flank. Although 4 longitudinal rows of foramina is typical, variations may occur, e.g., where an LLR may be reduced, and only foramina may be irregularly present .... *Spirobranchus zibrowii* n.sp.